BIOLOGICAL ASSESSMENT OF KLAMATH PROJECT'S CONTINUING OPERATIONS ON THE ENDANGERED LOST RIVER SUCKER AND SHORTNOSE SUCKER

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1.0 INTRODUCTION

1.1 Overview

The Bureau of Reclamation (Reclamation) is the responsible Federal agency for operation of the Klamath Project (Project). Operation of the Project has been subject to numerous previous consultations with the U.S. Fish and Wildlife Service under Section 7 of the Endangered Species Act. This biological assessment (BA) describes the effects of the action on federally listed species (shortnose sucker, Lost River sucker, bald eagle). The BA considers new scientific information regarding the endangered suckers in Upper Klamath Lake and other project waters. The implementation of a preferred alternative from the long-term operations plan (presently under development) would be the subject of future ESA consultation.

1.2 General Operation

The Klamath Project develops a water supply used for irrigation of approximately 220,000 acres in three counties in Oregon and California. Water supply for project deliveries comes from Upper Klamath Lake on the Klamath River and Gerber Reservoir on Miller Creek and Clear Lake Reservoir at the head of the Lost River in California. A detailed description of project facilities and their operation is included in the biological assessment prepared in 1992 (Reclamation 1992a) and the report describing historic project operation (Reclamation 2000a).

1.3 Background

There are various authorizations, responsibilities and obligations that affect or influence project operations. These include:

1) Project construction was authorized by the Secretary of the Interior on May 15, 1905, in accordance with the Reclamation Act of 1902. The Act of February 9, 1905 provides; "The Secretary of the Interior is hereby authorized in carrying out any irrigation project that may be undertaken by him under the terms and conditions of the national reclamation act and which may involve the changing of the levels of Lower or Little Klamath Lake, Tule or Rhett Lake, and Goose Lake, or any river or other body of water connected therewith, in the States of Oregon and California, to raise or lower the level of said lakes as may be necessary...";

2) The Klamath River Compact of 1957 entered into between the states of Oregon and California and approved by the U.S. Congress that established goals and objectives for the development and management of water resources of the Klamath River Basin;

3) FERC license, Project No. 2082, establishes terms and conditions for operation of the Eastside and Westside Powerplants at Link River Dam, J.C. Boyle, Copco No. 1 and No. 2, and Iron Gate hydroelectric projects and Keno Dam. This license sets certain minimum flows at IGD. Minimum flows, however, are subject to water availability and senior water rights. Pursuant to 1956 contract with Reclamation, PacifiCorp operates Link River Dam and its appurtenant power generation facilities. Reclamation and PacifiCorp entered into a Letter Agreement on June 5, 1997, to clarify for FERC that PacifiCorp was operating Link River Dam pursuant to Reclamation authority and directives under the 1956 contract, because the 1997 Klamath Project annual operations plan required Klamath River flows that were both greater and less than those included in PacifiCorp's FERC license. The Agreement has been extended each year to include that year's operation;

4) Endangered Species Act - Project operations affect four threatened and endangered species including the Lost River and shortnose sucker, southern Oregon/northern California coho salmon and bald eagle. In 1992, 1994, and 1996, the U.S. Fish and Wildlife Service (Service) issued biological opinions (BO) on the effects of the Project on the endangered suckers and bald eagles. The Service provided "reasonable and prudent alternatives" (RPAs) regarding water elevations in project reservoirs that would allow Project operation to continue without jeopardy to the listed species;

5) Tribal Trust - The United States has a trust responsibility to protect tribal trust resources. In general, the trust responsibility requires the United States to protect tribal fishing, gathering, hunting, and water rights, which are held in trust for the benefit of the tribes. Reclamation is obligated to ensure that Project operations not interfere with the

tribes' senior water rights. With respect to the tribes' fishing rights, Reclamation must, pursuant to its trust responsibility and consistent with its other legal obligations, prevent activities under its control that would adversely affect those rights, even though those activities take place off reservation. Fishery and other resources in the Klamath River and Upper Klamath Lake provide religious, cultural, subsistence, and commercial support for the Klamath Basin Indian tribes. The Klamath Basin Indian tribes include the Klamath, Hoopa Valley, Karuk, and Yurok Tribes; and

6) Refuge Water Supplies - Four national wildlife refuges lie adjacent to or within Project boundaries--Lower Klamath, Tule Lake, Clear Lake, and Upper Klamath Lake National Wildlife Refuges. The refuges either receive water from, or are associated with Project facilities.

1.4 Contracts and Water Rights

The Project supplies water to irrigation districts and individual irrigators pursuant to contracts entered into with Reclamation, subject to the availability of water. These contracts and water rights are described in the 1992 Biological Assessment (Reclamation 1992a) and Report on Historic Operation (Reclamation 2000a).

2.0 DESCRIPTION OF THE ACTION

Reclamation proposes continuing operation of the Klamath Project to supply water to project users and refuges. A detailed description of project operations is presented in the biological assessment prepared in 1992 (Reclamation 1992a) and the report describing historic project operation (Reclamation 2000a). This assessment focuses on water operations at the three main project reservoirs: Upper Klamath Lake, Clear Lake, and Gerber reservoir. Further, other operations associated with the Klamath Project are also described and assessed.

In addition to ongoing operation of the Project facilities, Reclamation proposes to support implementation of the Water Supply Initiative and Klamath Basin Water Supply Enhancement Act (P.L. 106-498). These activities would allow Reclamation to potentially increase and/or enhance Project water supplies.

2.1 Upper Klamath Lake

Reclamation proposes to operate the project to meet or exceed the elevations summarized in Table 1, depending on the water year type. These levels are the minimum end of the month values taken from historic operations (1960-1998). Water operations at Upper Klamath Lake are achieved through a combination of Eastside/Westside power canal releases, Link River Dam releases, A Canal releases, Lost River Diversion Canal releases, and Agency Lake Ranch diversions.

Table 1. Proposed minimum end of the month Upper Klamath Lake elevations by water year type (1960-1998).

Time Step	Above Average Water Years	Below Average Water Years	Dry Water Years	Critical Dry Water Years
October	4138.98	4138.36	4138.18	4136.93
November	4139.55	4138.99	4138.96	4137.80
December	4139.58	4138.80	4139.66	4138.58
January	4139.54	4139.41	4140.26	4140.01
February	4140.56	4140.15	4140.41	4140.94
March	4141.10	4141.35	4141.70	4141.80
April	4142.26	4142.15	4141.68	4141.68
May	4142.85	4142.22	4141.40	4140.70
June	4142.17	4141.30	4140.39	4139.45
July	4140.83	4140.00	4139.10	4138.77
August	4139.66	4138.85	4138.38	4137.52
September	4138.95	4138.18	4137.55	4136.84

2.2 Clear Lake Reservoir

Reclamation proposes to operate Clear Lake Reservoir to meet or exceed the elevations listed in Table 2, depending on the water year type. These elevations are the minimum end of the month values taken from historic operations (1960-1998).

A Safety of Dams (SOD) project is planned for Clear Lake Dam in 2001-2002 to correct the known safety deficiencies of the existing dam. There are presently operational restrictions upon the reservoir elevations because of the safety deficiencies. Reclamation plans to modify the dam site by constructing a roller-compacted concrete (RCC) embankment structure at the current dam site and subsequently breaching the existing embankment structure. The operational capacity of the reservoir would not change from its present capacity and the operational restrictions on the reservoir would be removed when the project is completed. As part of the SOD project, Reclamation plans to design and install a permanent fish screen on the dam's outlet structure. The screen would be operated during routine irrigation and Project releases, but not during flood releases. The effects of the SOD project are described in the environmental assessment (Reclamation 2000c) and are subject of a separate section 7 consultation.

Table 2. Proposed minimum end of the month Clear Lake Reservoir elevations by water year type (1960-1998).

Time Step	Above Average Water Year	Below Average Water Year	Dry Water Year	Critical Dry Water Year
October	4524.00	4521.33	4522.50	4519.30
November	4524.05	4521.47	4522.51	4519.29
December	4524.15	4521.70	4522.80	4519.35
January	4524.30	4521.87	4522.85	4519.40
February	4521.46	4523.37	4527.00	4523.00
March	4526.57	4524.25	4527.10	4522.84
April	4527.52	4525.50	4526.90	4522.75
May	4527.70	4525.10	4526.42	4521.77
June	4526.70	4524.08	4525.65	4521.18
July	4525.70	4522.88	4524.45	4520.44
August	4524.70	4521.90	4523.52	4519.82
September	4524.12	4521.28	4522.75	4519.42

2.3 Gerber Reservoir

Reclamation proposes to operate Gerber Reservoir to meet or exceed elevations listed in Table 3, depending on water year type. These elevations are the minimum end of month values taken from historic operations (1960-1998).

Table 3. Proposed minimum end of the month Gerber Reservoir elevations by water year type (1960-1998).

Time Step	Above Average Water Year	Below Average Water Year	Dry Water Year	Critical Dry Water Year
October	4815.18	4794.27	4797.98	4796.62
November	4815.16	4795.93	4797.96	4796.62
December	4815.20	4798.80	4798.04	4797.06
January	4816.58	4799.14	4798.18	4798.79
February	4802.23	4803.80	4804.82	4800.74
March	4821.30	4809.00	4804.18	4801.28
April	4827.30	4812.37	4808.26	4801.14
May	4827.00	4810.35	4808.10	4798.86
June	4824.10	4807.88	4803.60	4798.36
July	4820.81	4804.13	4799.22	4797.73
August	4817.98	4801.24	4798.60	4797.01
September	4815.26	4794.47	4798.08	4796.52

Reclamation's Denver Technical Service Center recently completed a cursory review of existing information to determine the feasibility of raising the active storage capacity of Gerber Dam by 3 feet. The review indicates that raising the dam is a viable option for increasing water storage in the Klamath Basin, although additional studies are needed to support this determination. Reclamation is beginning an appraisal study on raising the dam. Reclamation anticipates that this study will be completed in 2001. The additional water storage could be used to maintain minimum in-stream flows in Miller Creek for native fishes including endangered suckers or other Project purposes.

2.4 Lost River Dams/Diversion Facilities

Reclamation proposes to operate Malone, Wilson, and Anderson-Rose dams and associated diversion facilities consistent with historic operations. Reclamation proposes to inventory potential entrainment sites and develop an entrainment reduction plan prioritizing sites based on relative impacts to the species.

2.5 Agency Lake Ranch

In 1998, Reclamation acquired the 7,123-acre Agency Lake Ranch on the west side of Agency Lake at the north end of Upper Klamath Lake. The ranch property, comprised of former agricultural croplands and pasture, is being used to store additional water for Project use that would otherwise be spilled to the Klamath River during periods of high runoff. In 2000, approximately 15,000 acre-feet of additional water was stored on the ranch and subsequently pumped into Agency Lake for overall Project purposes. Existing dikes surrounding the ranch could be raised to store up to 35,000 to 40,000 acre-feet of spill water.

Reclamation proposes to continue operation of Agency Lake Ranch to store Project water as described in the April 17, 1998 letter to the Service. Reclamation has started a process for developing a long-term operations plan for the property.

2.6 1992 and 1994 Biological Opinion Provisions

The 1992 and 1994 BOs contained certain provisions (mitigation measures, RPAs, RPMs, ITS terms and conditions) that Reclamation is still planning to complete and/or implement. Reclamation is incorporating these planned and ongoing provisions as integral parts of the action.

2.6.1 Ongoing Mitigation Measures from the 1992 BO

1. Life history, population dynamics, and environmental factors affecting suckers - Reclamation believes that continued monitoring of sucker populations is essential to determining if sufficient progress is being made toward protection and recovery of the endangered suckers. Reclamation proposes to continue to support UKL sucker population status studies. UKL population monitoring objectives include: obtaining adult population indices and year class structure; and collect information focused on evaluation of management and ecosystem restoration actions.

2. Investigate feasibility of new storage in Lost River system - In 1998, Reclamation initiated a study in cooperation with the Klamath Compact Commission and the Department of Water Resources (Oregon and California) to evaluate a wide range of alternatives for supplemental water supplies in the Upper Klamath Basin. The Oregon Department of Water Resources in cooperation with USGS is studying groundwater in the Upper Klamath Basin. Reclamation hired a water conservation specialist to work with irrigation districts to conserve water and improve water quality. Also refer to the Klamath Basin Water Enhancement Act (P.L. 106-498).

2.6.2 Reasonable and Prudent Alternatives from 1992 and 1994 BO's

Implementation of the following s*elected* Reasonable and Prudent Alternatives, and Incidental Take Statement Reasonable and Prudent Measures and Terms and Conditions from the 1992 and 1994 BO's are included as part of the proposed action for this biological assessment.

2.6.2.1 Tule Lake RPA (as per July 22, 1992 BO)

1. The Project must be operated to assure a minimum surface elevation of 4034.6 feet from April 1st through September 30th of each year. A minimum elevation of 4034.0 feet must be maintained from October 1st to March 31st of each year.

2. A minimum flow of 30 cfs must be maintained in the Lost River below Anderson-Rose Dam for at least 4 weeks beginning April 15 of each year to allow spawning and return of adults and larval suckers.

2.6.3 Incidental Take Statement RPM's and Terms and Conditions-Suckers (as per July 22, 1992 BO)

1. Salvage Lost River and shortnose suckers that remain in the canal systems that emanate from Upper Klamath Lake, Clear Lake Reservoir, Tule Lake, and Gerber Reservoir after these canals have been shut down and drained.

2. Reclamation shall conduct an annual salvage of suckers stranded in the canal systems and below outlet structures of dams. A salvage plan must be presented to the Service and appropriate state agencies for their approval prior to any salvage operation.

2.6.4 New Action Items Incorporated into the Action

1. Tule Lake Integrated Land Management

Tule Lake sumps have been filling in with sediment since project development in the early 1900's and currently provides marginal habitat for endangered suckers. Waterfowl and bald eagle use of this area has also declined over the years due to habitat degradation. Wetland/agricultural land rotation has been identified as a potentially viable management strategy to restore wetland and lake ecosystem function and also support continued agricultural use concurrently. The Service and Reclamation have initiated pilot wetland/agricultural land rotation studies. Reclamation will assist the Service in the implementation of the wetland/agricultural land rotation program and support water quality and fish monitoring to assess the effectiveness of the program.

2. Lost River and Shortnose Sucker Recovery Plan

The Lost River and Shortnose Sucker Recovery Plan was written in 1993. Substantial new scientific information has been collected on sucker life history requirements, population status, and limiting factors. A revision of the Plan is necessary to provide criteria for species recovery and a strategy for restoration. Reclamation will assist the Service with this revision.

2.7 PacifiCorp Hydrofacilities Operations

PacifiCorp operates its facilities at the Westside and Eastside Plants at Link River Dam, Keno Dam, J. C. Boyle Dam, Copco No. 1 and Copco No. 2, and Iron Gate Dam as described in the 1996 biological assessment (Reclamation 1996a). Amore detailed review of their facilities, operations, and review of resource information is presented in the First Stage Consultation Document (FSCD) for the Klamath Hydroelectric Project (PacifiCorp 2000). This document was prepared in connection with the development of the hydroelectric license application that will be filed with the Federal Energy Regulatory Commission (FERC) for this existing Project. They are operating pursuant to a license with FERC that expires in 2006 and a biological opinion dated July 15, 1996 (USFWS 1996). PacifiCorp in November 1996 completed a flood operations review and risk assessment for Upper Klamath Lake. The proposed minimum “low range” elevations posed little threat to the overtopping of dikes around UKL except for February 15 when the “low range” elevation is 4141.5 feet. This elevation lies between the 100-year flood value of 4141.3 feet and 4142.1 feet for the 50-year flood value. Reclamation believes that PacifiCorp’s operations are covered under the 1996 BO and are not addressed in this biological assessment.

2.8 New Earth /Cell Tech Operations

New Earth operates and maintains an algae harvesting and processing facility at the head end of the C Canal under permit by Reclamation. A detailed description is provided in the 1996 BA (Reclamation 1996a) and BO (USFWS 1996). Reclamation believes that New Earth’s operations are covered under the 1996 BO and are not addressed in this biological assessment.

3.0 DESCRIPTION OF HISTORIC OPERATIONS

Reclamation has described actual operations of the project in this BA using historical data regarding Upper Klamath Lake, Gerber Reservoir, and Clear Lake Reservoir water elevations from October 1960 through September 1998. This period encompasses the time when existing project features/facilities have been in operation and it is the period of hydrological and project operation records incorporated into the water accounting spreadsheet model (KPOPSIM) for the Klamath Project.

Since 1995, Reclamation has operated the Klamath Project according to an annual operations plan. Each of these years through 2000 was an above average water year condition. The most recent annual operations plan is dated April 26, 2000 and covers the period of April 1, 2000 through March 31, 2001. The annual operations plans have been developed to assist Reclamation in operating the Klamath Project consistent with its obligations and responsibilities, given varying hydrological conditions. Project operation has been influenced during this period by events and actions such as: (1) varying hydrological conditions in the watershed from year to year; (2) changes in the Klamath River watershed and lands adjacent to Upper Klamath Lake; (3) changes in agricultural cropping patterns; (4) changes in national wildlife refuge operations; (5) previous consultations under Section 7(a)(2) of the ESA; (6) recognition of trust responsibilities for Klamath Basin Indian tribes, both upstream and downstream of the project; and (7) its obligation and responsibilities described in the July 25, 1995 and January 9, 1997 Regional Solicitor's memoranda.

Reclamation developed a water routing model (KPOPSIM) that simulates project operation, to assist evaluation of the impacts of varying water deliveries on overall project operations. It estimates the available water supply, including monthly runoff into Upper Klamath Lake and water demands at various locations. In addition, estimates of accretion flows downstream of project facilities have been developed by Reclamation. Operational criteria are incorporated into the model that includes administrative, legislative, legal, and contractual requirements. Using the model, monthly estimates of water deliveries to the various users, reservoir releases, in-stream flows at specific locations, reservoir storage, and pumping quantities can be determined. The model can simulate alternative operation scenarios that can be analyzed to predict the ability of the project to meet various water user demands. A detailed description of the model components, inputs, and assumptions is found in CH2M HILL (1998).

The 37 years of historic April through September net inflow data to Upper Klamath Lake (using 1996 bathymetric data) was used in a statistical analysis to determine the hydrologic year type indicators for the KPSIM water model. The first step was to determine if the data fit a normal distribution. Once this determination was made the arithmetic mean (average) was calculated (500,400 af). Next the standard deviation (based on sample) was calculated (187,600 acre-feet). Approximately 68% of the inflow years fall within the range of 500,400 +/- 187,600 af. The average minus one standard deviation equaled approximately 312,000 af. The water years between 500,000 af and 312,000 af are defined as below average inflow. Because there are significant operational spills for inflows above 500,000 af, the upper end of the area defined by mean plus one standard deviation was not used and 500,000 af was used as the above average indicator. For the boundary between critical and dry the mean minus 2 standard deviations was calculated and found to be lower than the lowest inflow on record. Since this couldn't be used, percentile rankings were developed for the full 37 years of inflow data and the third percentile was found to be 185,000 af and was used for the dry indicator. Anything below the dry indicator would be classified as a critical dry year. In summary, the net inflows for the four water year types (April through September) are: above average >500,000 af; below average 312,000-500,000 af; dry 185,000-312,000; and critical dry <185,000 af.

3.1 Upper Klamath Lake

Table 4 contains historical water surface elevation data for water years 1961- 1998 (October 1960-September 1998) based on PacifiCorp's daily records for the period of operation encompassed by this BA. This table summarizes the historical end of month minimum, maximum and average elevations for each water year type (above average, below average, dry and critical dry). All values are in feet above mean sea level (USBR datum). Figures 1-4 provide a graphical presentation of the historic data. The graphs have boxes whose upper and lower bounds represent the average +1 standard deviation and the average –1 standard deviation respectively, and lines running up and down from the boxes represent the magnitude of the maximum and minimum values.

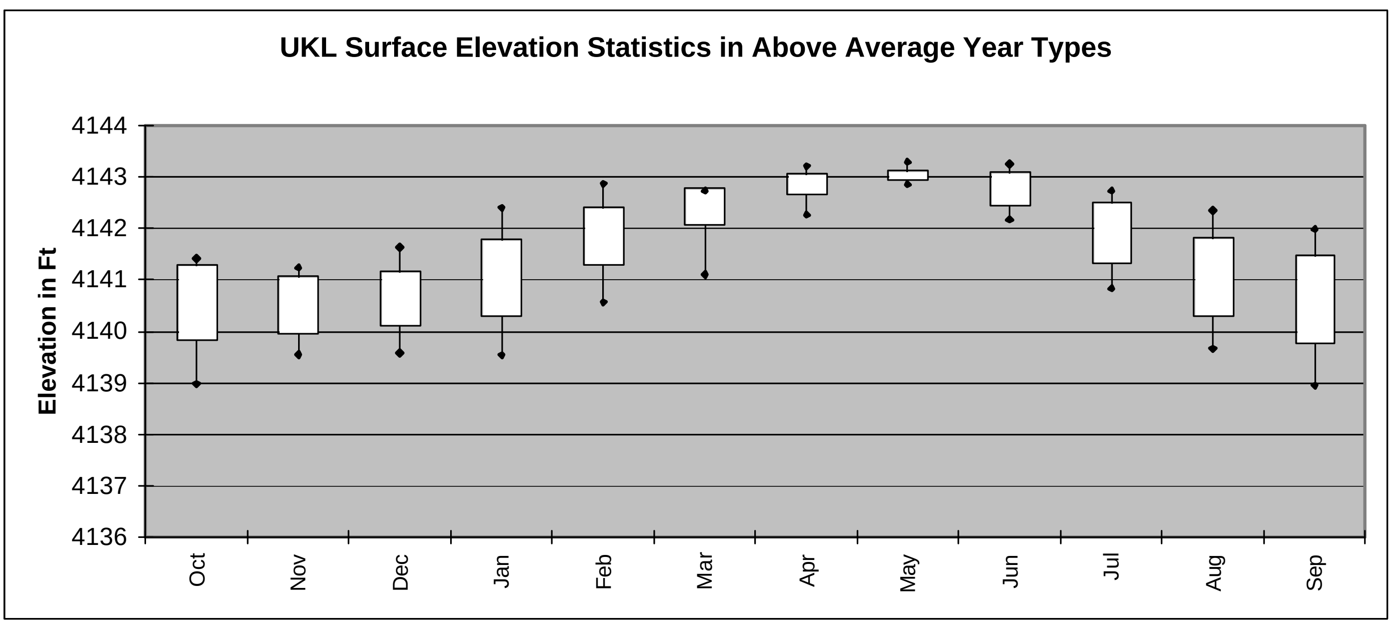
Table 4. End of the month Upper Klamath Lake elevations by water year type (1960-1998).

	20 Above Average Years				11 Below Average Years			
	Maximum	**Minimum**	**Average**	**St. Dev.**	**Maximum**	**Minimum**	**Average**	**St. Dev.**
Oct	4141.41	4138.98	4140.57	0.73	4141.35	4138.36	4139.51	0.82
Nov	4141.23	4139.55	4140.53	0.56	4141.21	4138.99	4140.00	0.72
Dec	4141.63	4139.58	4140.64	0.52	4143.50	4138.80	4140.60	1.09
Jan	4142.40	4139.54	4141.05	0.75	4143.02	4139.41	4140.96	1.00
Feb	4142.87	4140.56	4141.86	0.55	4142.20	4140.15	4141.41	0.68
Mar	4142.73	4141.10	4142.43	0.36	4142.73	4141.35	4142.25	0.37
Apr	4143.21	4142.26	4142.86	0.21	4143.06	4142.15	4142.68	0.25
May	4143.29	4142.85	4143.03	0.10	4143.16	4142.22	4142.64	0.30
Jun	4143.25	4142.17	4142.78	0.34	4142.79	4141.30	4142.05	0.47
Jul	4142.73	4140.83	4141.93	0.59	4141.91	4140.00	4140.97	0.61
Aug	4142.34	4139.66	4141.07	0.78	4141.80	4138.85	4140.07	0.81
Sep	4141.98	4138.95	4140.63	0.86	4141.46	4138.18	4139.53	0.84
	5 Dry Years				**2 Critical Years**			
	Maximum	**Minimum**	**Average**	**St. Dev.**	**Maximum**	**Minimum**	**Average**	**St. Dev.**
Oct	4139.60	4138.18	4138.66	0.50	4137.59	4136.93	4137.26	0.33
Nov	4140.50	4138.96	4139.78	0.51	4138.32	4137.80	4138.06	0.26
Dec	4141.81	4139.66	4140.70	0.72	4139.27	4138.58	4138.93	0.34
Jan	4141.54	4140.26	4141.12	0.46	4140.27	4140.01	4140.14	0.13
Feb	4142.38	4140.41	4141.62	0.67	4141.35	4140.94	4141.15	0.20
Mar	4142.84	4141.70	4142.42	0.43	4142.19	4141.80	4142.00	0.20
Apr	4142.95	4141.68	4142.44	0.49	4142.12	4141.68	4141.90	0.22
May	4142.85	4141.40	4142.43	0.54	4142.00	4140.70	4141.35	0.65
Jun	4142.45	4140.39	4141.63	0.71	4140.81	4139.45	4140.13	0.68
Jul	4140.86	4139.10	4140.21	0.63	4139.04	4138.77	4138.91	0.13
Aug	4139.78	4138.38	4139.11	0.50	4137.72	4137.52	4137.62	0.10
Sep	4139.45	4137.55	4138.49	0.62	4137.43	4136.84	4137.14	0.30

Above Average Year

Above average years occurred in 20 of the 38 hydrologic years utilized for this assessment (52.6%). The minimum elevation ranged from 4138.95 at the end of September to 4142.85 at the end of May. The average ranged from 4140.53 at the end of November to 4143.03 at the end of May (Table 4, Figure 1).

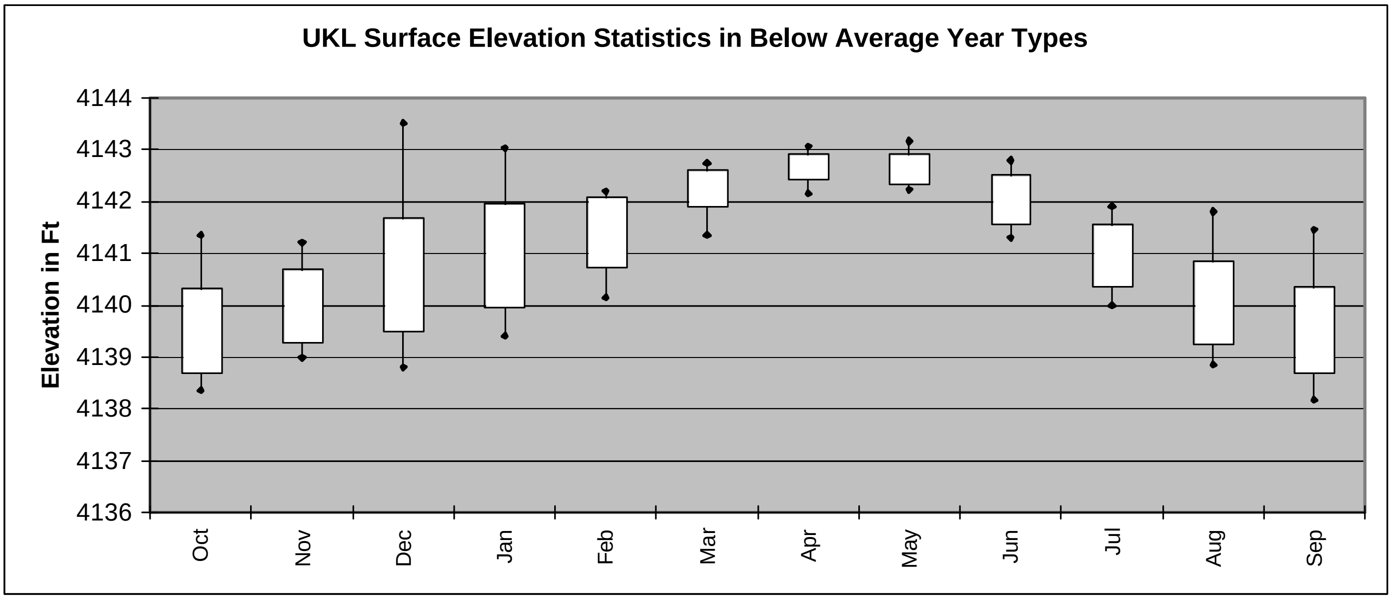
Figure 1. Upper Klamath Lake end of month elevations (1960-1998) for above average water years.



Below Average Year

Below average years occurred 11 of the 38 hydrologic years utilized for this assessment (28.9%). The minimum end of the month elevation ranged from 4138.18 in September to 4142.22 in May (Table 4, Figure 2). The average end of the month elevation ranged from 4139.51 in October to 4142.68 in April.

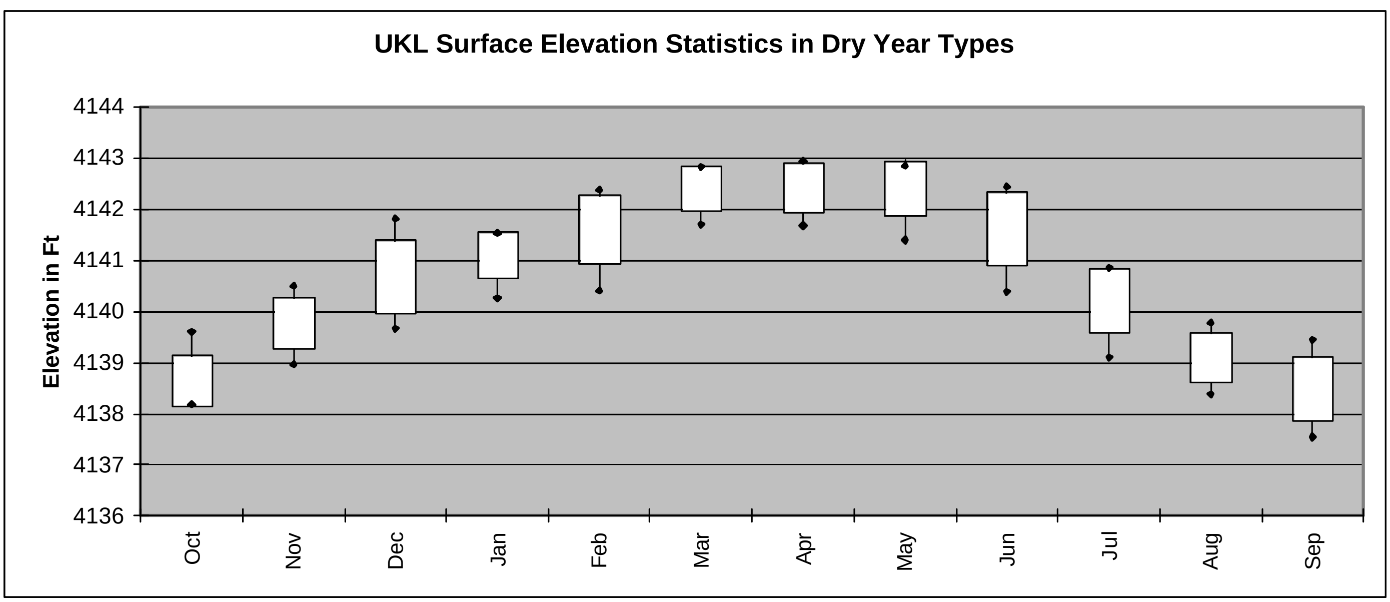
Figure 2. Upper Klamath Lake end of month elevations (1960-1998) for below average years.



Dry Year

Dry water years occurred 5 out of 38 years hydrologic years utilized for this assessment (13.2%). The minimum end of the month elevation ranged from 4137.55 in September to 4141.70 in March (Table 4, Figure 3). The average end of the month elevation ranged from 4138.49 in September to 4142.44 in April.

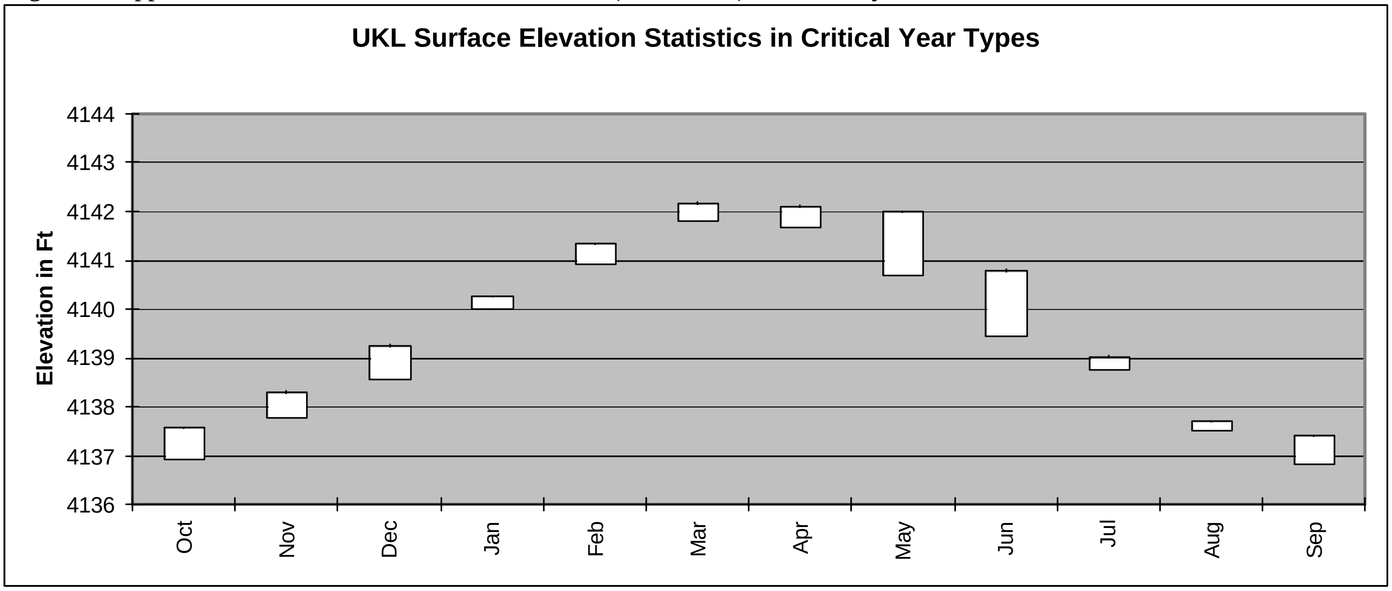
Figure 3. Upper Klamath Lake end of month elevations (1960-1998) for dry water years.



Critical Dry Year

Critical dry years occurred in 2 of the 38 hydrologic years utilized for this assessment (5.3%). The minimum end of month elevation ranged from 4136.84 in September to 4141.80 March (Table 4, Figure 4). The average end of the month elevation ranged from 4137.14 for September to 4142.00 for March.

Figure 4. Upper Klamath Lake end of month elevations (1960-1998) for critical years.



3.2 Clear Lake Reservoir

Statistics on historical water surface elevation data for water years 1961-1998 (October 1960-September 1998) are summarized by water year type in Table 5. Figures 5-8 provide a graphical presentation of the data.

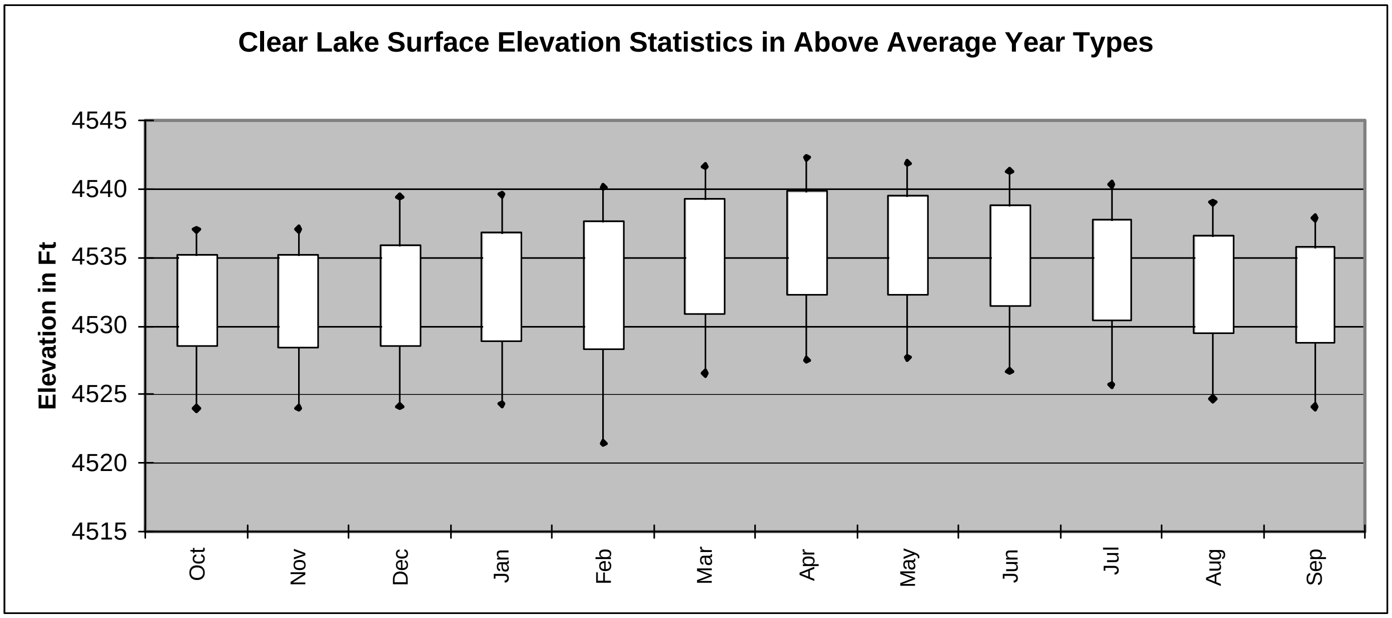
Table 5. End of the month Clear Lake Reservoir elevations by water year type (1960-1998).

	20 Above Average Years				11 Below Average Years			
	Maximum	Minimum	Average	St. Dev.	Maximum	Minimum	Average	St. Dev.
Oct	4537.02	4524.00	4531.90	3.37	4532.60	4521.33	4527.05	3.33
Nov	4537.05	4524.05	4531.87	3.41	4532.96	4521.47	4527.17	3.36
Dec	4539.43	4524.15	4532.21	3.70	4533.78	4521.70	4527.86	3.37
Jan	4539.60	4524.30	4532.93	3.98	4535.44	4521.87	4528.70	3.75
Feb	4540.11	4521.46	4532.97	4.68	4536.50	4523.37	4530.18	4.37
Mar	4541.63	4526.57	4535.07	4.21	4537.45	4524.25	4530.91	4.35
Apr	4542.28	4527.52	4536.08	3.80	4537.15	4525.50	4531.25	3.81
May	4541.89	4527.70	4535.91	3.67	4536.50	4525.10	4530.66	3.69
Jun	4541.27	4526.70	4535.16	3.68	4535.84	4524.08	4529.96	3.69
Jul	4540.33	4525.70	4534.14	3.66	4534.70	4522.88	4528.81	3.77
Aug	4538.97	4524.70	4533.08	3.57	4533.65	4521.90	4527.86	3.80
Sep	4537.86	4524.12	4532.29	3.49	4532.86	4521.28	4527.17	3.78
	5 Dry Years				**2 Critical Years**			
	Maximum	**Minimum**	**Average**	**St. Dev.**	**Maximum**	**Minimum**	**Average**	**St. Dev.**
Oct	4528.30	4522.50	4525.38	1.91	4521.54	4519.30	4520.42	1.12
Nov	4528.30	4522.51	4525.71	1.85	4521.65	4519.29	4520.47	1.18
Dec	4528.48	4522.80	4526.60	2.05	4521.96	4519.35	4520.66	1.30
Jan	4529.02	4522.85	4527.45	2.32	4525.89	4519.40	4522.65	3.24
Feb	4532.00	4527.00	4529.45	1.83	4526.20	4523.00	4524.60	1.60
Mar	4532.68	4527.10	4529.85	1.87	4526.30	4522.84	4524.57	1.73
Apr	4532.54	4526.90	4529.59	1.83	4525.84	4522.75	4524.30	1.54
May	4532.18	4526.42	4529.14	1.87	4525.39	4521.77	4523.58	1.81
Jun	4531.20	4525.65	4528.28	1.81	4524.49	4521.18	4522.84	1.66
Jul	4530.20	4524.45	4527.11	1.87	4523.16	4520.44	4521.80	1.36
Aug	4529.13	4523.52	4526.18	1.86	4521.43	4519.82	4520.63	0.80
Sep	4528.30	4522.75	4525.52	1.88	4521.70	4519.42	4520.56	1.14

Above Average Year

The minimum end of the month elevation ranged from 4524.00 in October to 4527.70 in May (Table 5, Figure 5). The average end of the month elevation ranged from 4531.87 in November to 4536.08 in April.

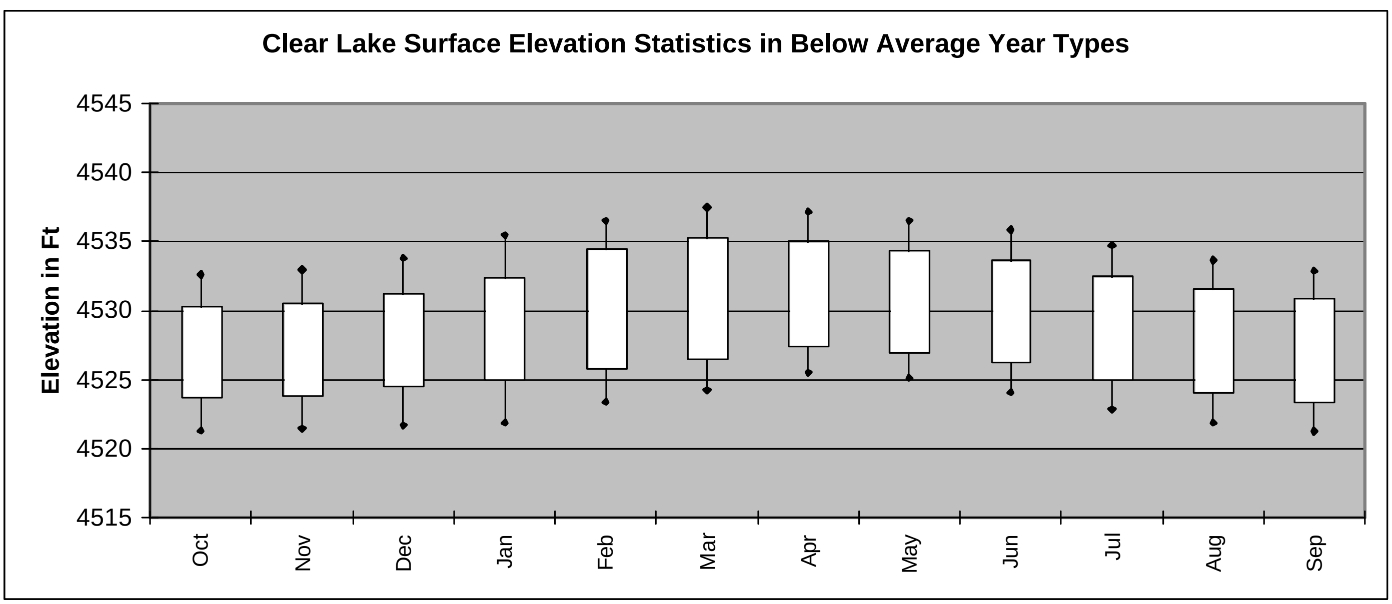
Figure 5. Clear Lake Reservoir end of month elevations (1960-1998) for above average years.



Below Average Year

The minimum end of the month elevation ranged from 4521.28 in September to 4525.50 in April (Table 5, Figure 6). The average end of the month elevation ranged from 4527.05 in October to 4531.25 in April.

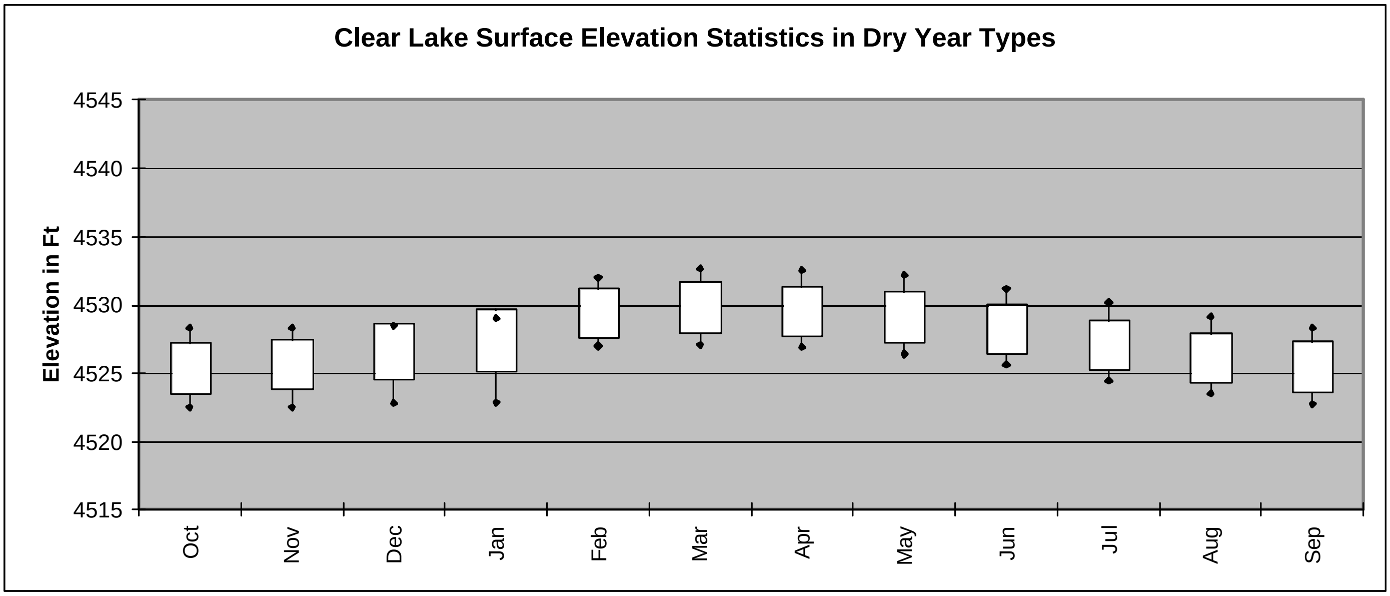
Figure 6. Clear Lake Reservoir end of month elevations (1960-1998) for below average years.



Dry Year

The minimum end of the month elevation ranged from 4522.50 in October to 4527.10 in March (Table 5, Figure 7). The average end of the month elevation ranged from 4525.38 in October to 4529.85 in March.

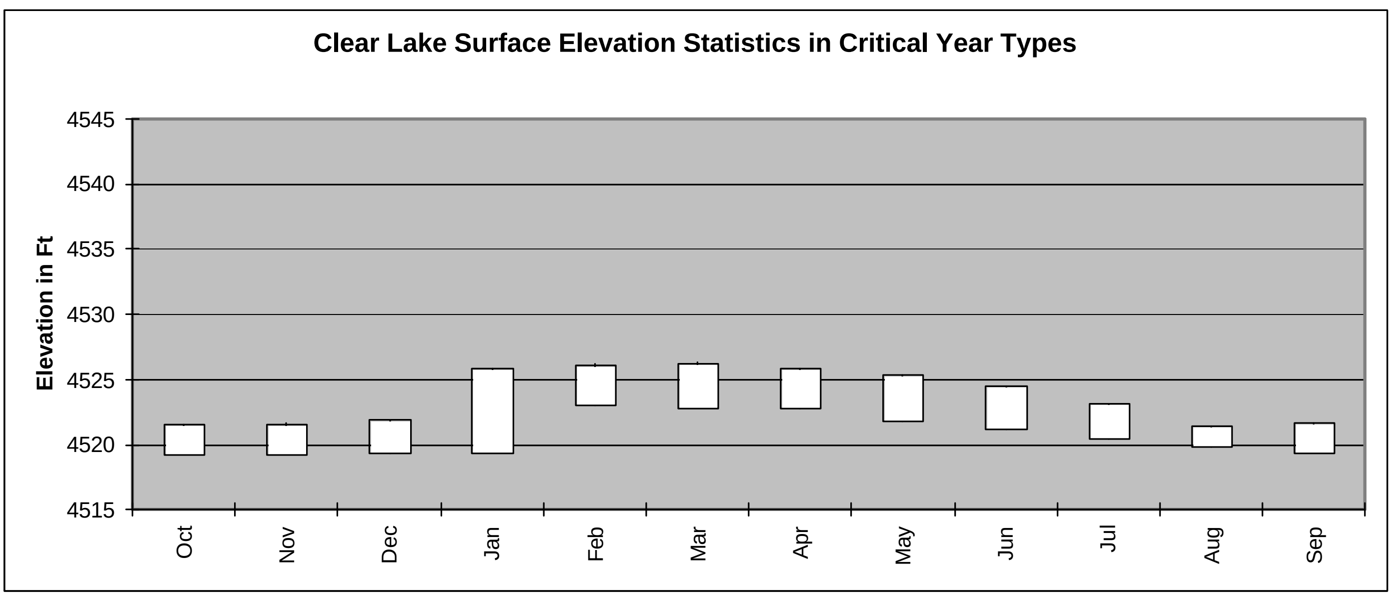
Figure 7. Clear Lake Reservoir end of month elevations (1960-1998) for dry years.



Critical Dry Year

The minimum end of the month elevation ranged from 4519.29 in November to 4523.00 in February (Table 5, Figure 8). The average end of the month elevation ranged from 4520.42 in October to 4524.60 in February.

Figure 8. Clear Lake Reservoir elevations (1960-1998) by month for critical dry years.



3.3 Gerber Reservoir

Statistics on Gerber Reservoir historical water surface elevation data for water years 1961-1998 (October 1960-September 30, 1998) are summarized by water year type in Table 6.

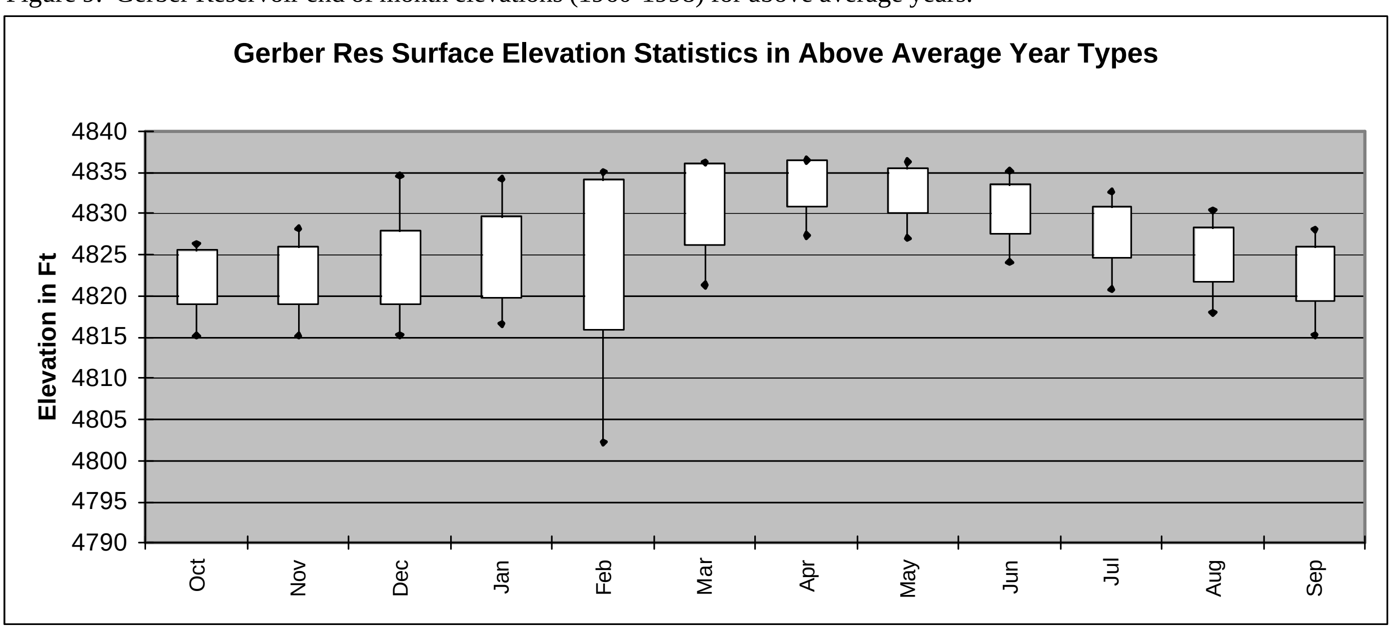
Table 6. End of the month Gerber Reservoir elevations by water year type (1960-1998).

	20 Above Average Years				11 Below Average Years			
	Maximum	**Minimum**	**Average**	**St. Dev.**	**Maximum**	**Minimum**	**Average**	**St. Dev.**
Oct	4826.26	4815.18	4822.30	3.32	4821.49	4794.27	4810.09	8.00
Nov	4828.12	4815.16	4822.54	3.55	4823.04	4795.93	4810.89	7.91
Dec	4834.60	4815.20	4823.50	4.49	4831.40	4798.80	4814.01	9.16
Jan	4834.18	4816.58	4824.79	4.94	4829.70	4799.14	4815.54	9.37
Feb	4835.04	4802.24	4825.11	9.14	4832.03	4803.80	4819.94	7.85
Mar	4836.19	4821.30	4831.21	5.00	4835.00	4809.00	4823.32	7.49
Apr	4836.48	4827.30	4833.75	2.85	4834.59	4812.37	4825.40	5.94
May	4836.29	4827.00	4832.83	2.71	4832.57	4810.35	4823.20	5.75
Jun	4835.16	4824.10	4830.66	2.99	4830.03	4807.88	4820.67	6.04
Jul	4832.68	4820.81	4827.80	3.19	4826.78	4804.13	4817.16	6.33
Aug	4830.39	4817.98	4825.00	3.34	4823.64	4801.24	4814.01	6.61
Sep	4828.00	4815.26	4822.76	3.39	4821.63	4794.47	4810.77	7.86
	5 Dry Years				**2 Critical Years**			
	Maximum	**Minimum**	**Average**	**St. Dev.**	**Maximum**	**Minimum**	**Average**	**St. Dev.**
Oct	4809.20	4797.98	4803.25	3.64	4806.59	4796.62	4801.61	4.99
Nov	4811.50	4797.96	4805.52	4.78	4806.74	4796.62	4801.68	5.06
Dec	4821.60	4798.04	4808.91	7.84	4807.08	4797.06	4802.07	5.01
Jan	4822.20	4798.18	4811.02	8.61	4816.63	4798.79	4807.71	8.92
Feb	4825.65	4804.82	4816.35	6.69	4822.94	4800.74	4811.84	11.10
Mar	4825.91	4804.18	4817.55	7.24	4823.30	4801.28	4812.29	11.01
Apr	4824.71	4808.26	4818.08	5.58	4822.48	4801.14	4811.81	10.67
May	4822.84	4808.10	4816.55	4.91	4820.80	4798.86	4809.83	10.97
Jun	4819.52	4803.60	4813.29	5.39	4817.81	4798.36	4808.09	9.73
Jul	4815.48	4799.22	4809.19	5.55	4814.08	4797.73	4805.91	8.18
Aug	4812.90	4798.60	4806.10	4.70	4810.16	4797.01	4803.59	6.57
Sep	4809.64	4798.08	4803.37	3.74	4806.78	4796.52	4801.65	5.13

Above Average Year

The minimum end of the month elevation ranged from 4802.24 in February to 4827.30 in April (Table 6, Figure 9). The average end of the month elevation ranged from 4826.26 in October to 4836.48 in April.

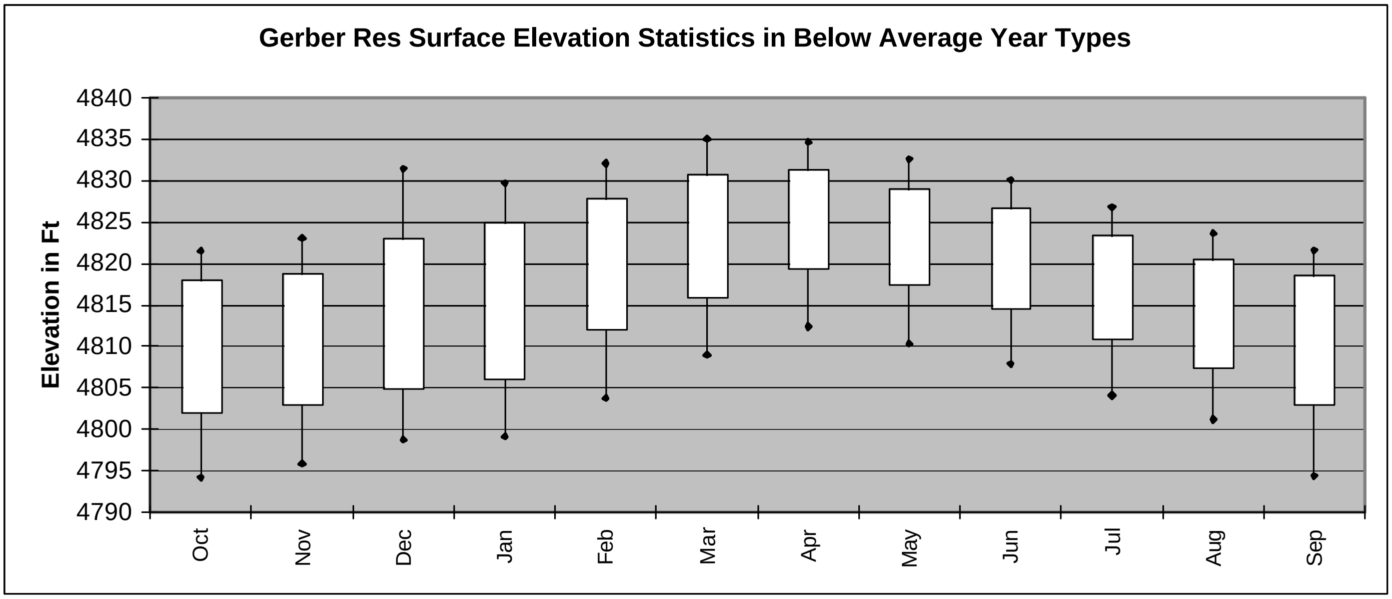
Figure 9. Gerber Reservoir end of month elevations (1960-1998) for above average years.



Below Average Year

The minimum end of the month elevation ranged from 4794.27 in October to 4812.37 in April (Table 6, Figure 10). The average end of the month elevation ranged from 4810.09 in October to 4825.40 in April.

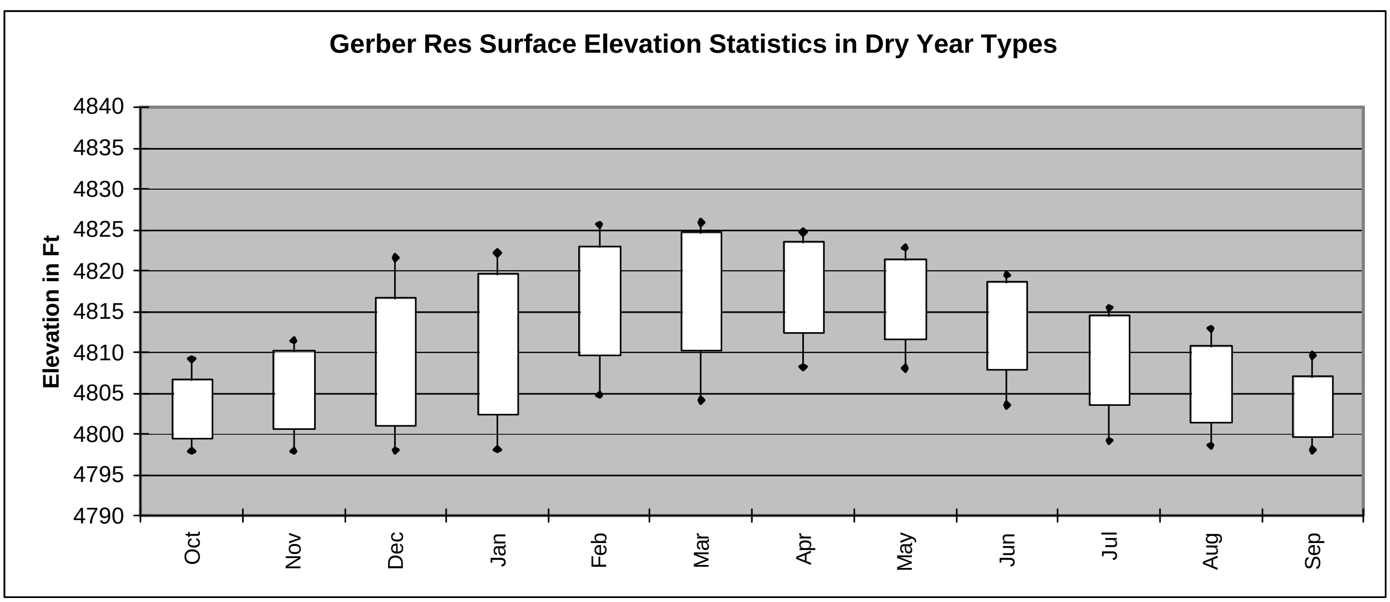
Figure 10. Gerber Reservoir end of month elevations (1960-1998) for below average years.



Dry Year

The minimum end of the month elevation ranged from 4797.98 in October to 4808.26 April (Table 6, Figure 11). The average end of the month elevation ranged from 4803.25 in October to 4818.08 in April.

Figure 11. Gerber Reservoir end of month elevations (1960-1998) for dry years.

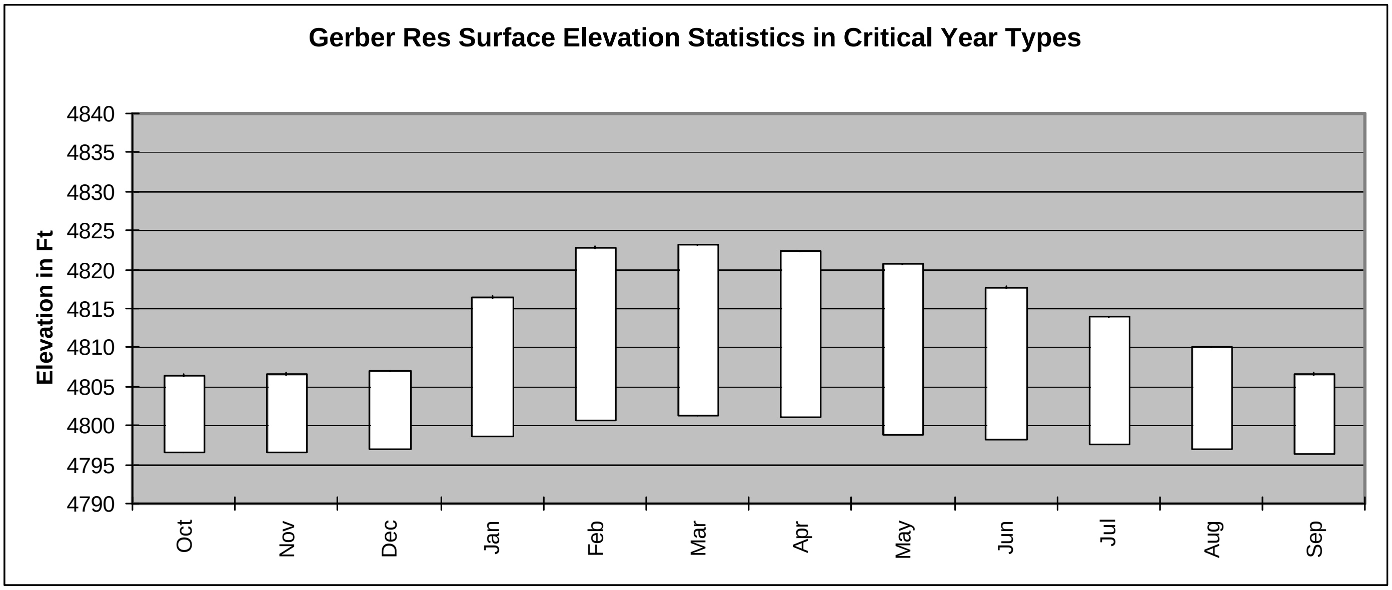


Critical Dry Year

The minimum end of the month elevation ranged from 4796.52 in September to 4801.28 in March (Table 6, Figure

12). The average end of the month elevation ranged from 4801.61 in October to 4812.29 in March.

Figure 12. Gerber Reservoir end of month elevations (1960-1998) for critical dry years.



3.4 Agricultural and Refuge Water Use

Water is diverted from Project storage facilities to provide for crop production and needs on National Wildlife Refuges located within the Project service area (Table 7).

Table 7. Crop and Refuge Water Use from Upper Klamath Lake (1961 through 1999–values in 1,000s of acre-feet).

	19 Above Average Years			11 Below Average Years		
Time Step	Maximum	Minimum	Average	Maximum	Minimum	Average
October	28.9	6.58	17.78	27.77	12.34	18.53
November	15.86	.49	6.78	14.25	2.28	6.81
December	17.28	.39	8.68	16.43	1.52	8.5
January	22.74	5.43	12.43	23.57	6.24	13.79
February	17.64	2.33	7.28	11.10	2.94	8.03
March	12.87	.3	4.69	10.68	1	6.07
April	52.85	5.49	21.14	52.85	21.92	36.17
May	76.70	28.95	55.15	81.83	50.55	65.49
June	103.54	45.33	81.72	102.05	73.11	86.17
July	105.38	75.33	91.35	104.55	75.37	93.25
August	87.20	47.71	74.63	88.58	36.08	71.50
September	61.45	34.63	48.09	60.95	40.15	48.76

Table 7. Continued--Crop and Refuge Water Use from Upper Klamath Lake (1961-1999—values in 1000s of af).

	5 Dry Years			2 Critical Years		
Time Step	Maximum	Minimum	Average	Maximum	Minimum	Average
October	29.13	8.83	20.50	31.17	14.62	22.90
November	16.52	1.5	6.15	9.51	5.57	7.54
December	17.09	6.15	11.99	20.33	15.26	17.80
January	20.67	9.33	13.72	19.70	11.14	15.42
February	12.12	2.23	7.27	12.60	7.35	9.98
March	17.99	1.75	10.15	16.30	11.07	13.69
April	67.32	27.11	41.53	63.63	57.64	60.64
May	58.73	37.60	50.47	90.12	51.50	70.81
June	91.75	70.99	81.70	87.66	78.67	83.17
July	99.81	87.40	95.28	103.77	58.25	81.01
August	83.48	76.26	79.37	90.84	64.91	77.88
September	66.07	49.63	58.56	33.46	32.15	32.81

4.0 ENDANGERED SPECIES POTENTIALLY AFFECTED BY THE KLAMATH RECLAMATION PROJECT

4.1 Introduction

Reclamation first formally consulted on the effects of long-term operation of the Klamath Project on the bald eagle, Lost River sucker, shortnose sucker and American Peregrine Falcon in 1992. A biological assessment was completed on February 28, 1992 and the U.S. Fish and Wildlife Service completed a biological opinion on July 22, 1992. The Service also wrote a recovery plan for the Lost River and shortnose sucker in April 1993 (USFWS 1993). Proposed Critical Habitat was designated in 1994. Descriptions of the general biology and life history of these species can be found in these documents. Additional information on the species can be found in the biological assessment completed on January 20, 1994 for Clear Lake (Reclamation 1994c) and associated biological opinion completed August 11, 1994 (USFWS 1994b) and June 15, 1996 biological assessment (Reclamation 1996a) and July 15 biological opinion on PacifiCorp and The New Earth Company operations (USFWS 1996). Substantial research and monitoring activities have been completed over the last few years particularly for Upper Klamath Lake suckers and their habitat. This biological assessment provides a summary of pertinent new scientific information not reported in these documents.

4.2 Bald Eagle (Haliaeetus leucocephalus)

Refer to the Pacific Bald Eagle Recovery Plan (USFWS 1986) and 1992 Biological Assessment on Long-term Klamath Project Operations for a review of information on bald eagles (Reclamation 1992a). Additional information is documented in biological opinions written by the Service during formal consultation on the effects of the long-term operation of the Klamath Project on the Lost River sucker, shortnose sucker, bald eagle, and American peregrine falcon, pursuant to section 7 of the Endangered Species Act of 1973 (USFWS 1992, 1994b).

In March 1997, Reclamation and the Service convened a meeting with bald eagle experts to discuss information on bald eagle life history, habitat requirements, Klamath Basin distribution and abundance, and potential impacts of Klamath Project and Klamath Basin National Wildlife Refuge operations.

Bald eagle populations in the Klamath Basin are comprised of three types of bird groups: 1) breeding adult pairs; 2) non-breeding immature and sub-adults; and 3) wintering birds, including many migratory adults which breed in other areas as far away as Canada.

Year-round resident bald eagles include approximately 200 breeding adults, and 75+ non-breeding juveniles (Ralph Opp, Oregon Eagle Foundation, per. com.). During winter an additional 200-700 birds migrate to the basin from all over the interior western U.S. and Canada. Based on counts performed in January, the Klamath Basin has supported 10-50% of the bald eagles in Oregon. Wintering bald eagle use of the California side of the basin (including Tule Lake NWR) regularly accounts for approximately 50% of the bald eagles wintering in California. Winter migrants begin to arrive in mid-October and begin to disperse in March and April with peak numbers in late January and February. Breeding birds may occupy nesting territories from January through August. They nest in March and April, raise young from April – August, and young birds fledge from July – September (R. Opp, OEA, per. com).

Bald eagles are opportunistic feeders; they prefer live prey particularly fish during the nesting season while in the winter they frequently scavenge on waterfowl and other animals. In the Klamath Basin bald eagles feed on rodents during the later fall and early winter as agricultural lands in the Lower Klamath Lake area are flooded. In winter they rely mostly on concentrations of migratory waterfowl.

At UKL, important prey species during eagle nesting season include tui chub, blue chub, and suckers (Frezel 1984). Species composition of eagle prey at Gerber Reservoir has not been documented. The reservoir's fishery resource consists largely of introduced species such as yellow perch, crappie, brown bullheads, pumpkinseed, and also native redband trout and shortnose suckers.

About 30 nesting pairs of bald eagles are associated with UKL with about 115 occupied nesting territories in the basin. Other nesting areas include Gerber Reservoir, J.C. Boyle, Klamath River, and the Lost River. No bald eagle breeding territories are known from the area around Clear Lake. Eight territories are potentially within foraging distance of the Tule Lake NWR and Lower Klamath Lake NWR. Average productivity has been about one bird per occupied territory per year. These resident birds probably mix with migrants during the winter and appear to rely heavily on food resources at the Lower Klamath NWR during winter. The condition of adults going through winter is important for nesting success and productivity.

The Klamath Basin is an important wintering area for bald eagles because of the abundant food resources (mostly waterfowl) and night roosting areas close to the feeding areas. Lower Klamath NWR is very important to wintering bald eagles because it has both abundant food and night roosting areas nearby. Several hundred birds concentrate there depending on weather and food supply and thus can be quite variable from year to year. The majority of the birds that winter in the Basin are not local birds but come from many interior western states and Canada.

The three main winter feeding areas are: Lower Klamath NWR, Tule Lake NWR, and the agricultural lands adjacent to the refuges. Areas used for foraging include both privately owned agricultural lands and State and Federal wildlife refuges. The relationship between the number and distribution of waterfowl, ice cover and water management influences the food source for eagles during the stressful winter season and thereby, the presence of eagles. The large numbers of wintering birds is supported by the use of four main winter roosts: Bear Valley NWR, Sisters, Cougar Caldwell and Mt. Dome. These roosts are used in conjunction with three main feeding areas.

Traditionally all three feeding areas were used each year by wintering bald eagles. In the last 10 years Tule Lake NWR has been almost abandoned as a feeding area largely due to a lack of waterfowl presence in the winter. This can be readily seen in the records of use of bald eagles and the number and presence of waterfowl on Tule Lake NWR. The Klamath Basin National Wildlife Refuges have monitored waterfowl and bald eagle use of the Tule Lake and Lower Klamath Lake Refuges each year since 1984 (Jim Hainline, Klamath Basin Refuges, per. com.). Monthly counts of bald eagles during January at both refuges were strongly correlated with waterfowl numbers. Waterfowl numbers at Tule Lake have decreased between 1984 and 1999 and bald eagle numbers have fallen similarly. The decline in waterfowl use appears to be related to the loss of extensive areas of emergent wetlands. The loss of these wetlands was associated with water operations that maintain relatively constant water levels in Tule Lake sumps. Reclamation and the Service are jointly working on a wetland/agricultural land rotation program to restore wetlands in the Tule Lake area.

Waterfowl use of the Lower Klamath NWR is dependent in part on the total wetland area flooded during the fall migration. Also during extremely cold weather when the wetlands are frozen waterfowl use declines. In the winter of 1992-1993 a deep freeze all but eliminated waterfowl presence and eagle numbers actually increased in the area likely bolstered from wintering birds from other areas where food was even more scarce. Wintering eagles were seen feeding on roadkills and in areas nearer humans that recorded before.

New wetlands restored at Tulana Farms, Wood River Ranch, Agency Lake Ranch, and Running Y Ranch Resort provide habitat for waterfowl and attract bald eagles that forage on them.

4.3 Endangered Suckers

4.3.1 Lost River sucker (Deltistes luxatus)

Refer to the following documents for information on biology, distribution and abundance, taxonomy, reasons for decline, age and growth, and reproduction: 1992 Biological Assessment on Long-term Klamath Project Operations (Reclamation 1992a), 1992 Biological Opinion on the Effects of the Long-term Operation of the Klamath Project on the Lost River Sucker, Shortnose Sucker, Bald Eagle, and American Peregrine Falcon (USFWS 1992, USFWS 1994b), Recovery Plan for the Lost River Sucker and Shortnose Sucker (USFWS 1993), and Lost River and Shortnose Sucker Proposed Critical Habitat Biological Support Document (USFWS 1994a), 1996 Biological Assessment of PacifiCorp and The New Earth Company Operations associated with the Klamath Project (Reclamation 1996), 1996 Biological Opinion on PacifiCorp and the New Earth Company Operations, as permitted by Bureau of Reclamation for the Lost River Sucker and Shortnose Sucker (USFWS 1996).

4.3.2 Shortnose sucker (Chasmistes brevirostris) – Same as for Lost River sucker.

4.4 New Scientific Information – Endangered Suckers

The new scientific information reviewed in this BA generally represents data collected since the 1996 BA (Reclamation 1996a). Other documents referenced above review the earlier information.

4.4.1 UPPER KLAMATH LAKE

4.4.1.1 Spawning Runs - Sprague River Dam Fish Ladder

The Klamath Tribes have monitored sucker spawning runs at the Sprague River Dam fish ladder intermittently since the early 1980's (Bienz and Ziller 1987; Klamath Tribes, unpublished data). In 1996, the Tribes monitored the ladder cells on 17 dates between February 15 and May 30. During sampling, the ladder was blocked off and water levels lowered to allow for sampling of all cells with dipnets. One-hundred-fifty-seven shortnose suckers were captured from May 8 to May 30 including 72 females and 85 males. Shortnose spawners ranged from 320 to 470 mm FL (mean 375 mm FL). Males averaged 350 mm FL and females 400 mm FL.

Two Lost River suckers were captured March 20 and one on March 21. This species was not captured again until May 8. From this date until May 30 substantial numbers were captured each day sampled. Sampling was discontinued at the end of May because most fish captured were spawned out fish migrating downstream. Eighty-two females and 57 males were captured. They ranged from 260 mm FL to 560 mm FL. Mean length of both males and females was 450 mm FL. Upstream movements of both Lost River and shortnose suckers appeared to peak the first two weeks of May and they moved back downstream in late May to early June. Many fish were tagged with Floy anchor tags in the dorsal musculature below the dorsal fin.

Most Lost River suckers ranged from 400-500 mm FL similar to the length distribution from trammel netting at the mouth of the Williamson River (National Biological Service-NBS 1996). Adults greater than 560 mm were not captured in the fish ladder at the Sprague River dam although 8% of the fish captured in the lower Williamson River were in this size range. This is consistent with observations in the 1980's when large Lost River suckers were common below the dam, but rare or absent in the ladder (Coleman et al. 1988). The lack of large Lost River suckers in the ladder could be due to the inability to ascend the ladder, a general aversion to the ladder, or a preference for spawning in areas downstream of the ladder. Minimal differences in size distribution existed between shortnose suckers captured in the fish ladder and those captured in the Williamson River (NBS 1996).

The Sprague River Dam fish ladder was monitored on 34 dates in 2000 (Rip Shivley, BRD, per. com.). Between March 8 and June 7 over 1,400 suckers were captured. There appeared to be at least two distinct peaks of suckers moving through the ladder. The early peak during the later half of March consisted mainly of Klamath largescale suckers and a group that displayed intermediate characteristics between Klamath largescale and Lost River suckers. The second peak of fish in April consisted mostly of Lost River suckers with some shortnose suckers. Catches dropped to near zero after May 4. Catches did not appear to be correlated with air or water temperature, or stream flow although most fish were captured on the rising limb of the hydrograph.

A small number of Lost River suckers were captured in late March suggesting that there may be a small early run of this species. In the third week of March 1995, Lost River suckers were observed spawning at Kirk Spring in the upper Sprague River (Larry Dunsmoor, Klamath Tribes, per. com.).

Lost River suckers ranged from 347-675 mm FL with a mean of 530 mm FL (n=549). Shortnose suckers ranged from 300-531mm FL with a mean of approximately 400 mm FL (n=103). Minimal size distribution differences were noted between Lost River and shortnose suckers captured in the fish ladder and those from the lower Williamson River. However, large Lost River suckers were less abundant in the ladder than in trammel net catches in the lower Williamson. The sex ratios (male to female) of fish captured were skewed towards females for Lost River and shortnose suckers.

The rate of occurrence of lamprey wounds varied by species. Shortnose and Lost River suckers had a higher rate of lamprey wounds (55-60%) as compared to Klamath largescale and the largescale-like group (30-35%). Most fish had 1-2 lamprey wounds. Sixty-five fish were captured that had been tagged in previous years sampling. The majority of these fish were originally tagged at the Sprague River Dam fish ladder. Most of the recaptured fish were Klamath largescale or largescale-like fish. Only three Lost River suckers and one shortnose sucker were previously tagged. Given the large number of Lost River suckers (n=647) and the low percentage of recaptured fish, we believe this run of Lost River suckers has been relatively unsampled in the past.

4.4.1.2 Adult Population Monitoring - Lower Williamson River

From 1995 to 2000, BRD and OSU monitored adult suckers near the mouth of the Williamson River as they migrated upstream to spawn (Perkins et al. 2000a; Markle et al. 2000a; Rip Shively, BRD, per. com.). Sampling techniques were similar each year allowing interannual comparisons. Adult abundance index values for both sucker species declined continuously over the five-year period (1995-1999). The adult abundance index represents catch per unit effort for the sample period after 8am. Shortnose sucker values dropped from 175 in 1995 to 12 in 1999. Lost River sucker abundance values declined from 20 in 1995 to 1.5 in 1999. In 2000, index values increased for both species but were much lower than those from 1995 for both species and shortnose suckers in 1996 (Rip Shively, BRD, per. com.).

Interannual comparisons of the adult monitoring data are affected by different start dates ranging from mid-February (1998) to mid-April (1999). Stop dates also differed, being as early as late May in 1998 and as late as early August (1999). During two sampling years, 1995 and 1999, catches on the first sampling date were high, suggesting underestimation of early spawners.

In addition, trammel net catches are dependent on fish behavior. In 1997 and 1998, diel studies indicated that the migration of suckers in the lower Williamson River were several times higher in early morning (0500-0730) and evening (1800-2200 h) than other times of the day (Perkins et al. 2000a). In 1999, Markle et al. (2000a) documented a similar pattern of high early morning catch rates. BRD sampled from early morning (0500-0600) until 1000-1200 in 2000. No evening sampling was conducted in 1999 or 2000.

Cues other than time of day may also be important in the timing of sucker movements. Perkins et al. (2000a) noted that temperature appeared to cue migrations with peak movements occurring at 10-15 C. Markle et al. (2000a) found similar temperature ranges during migrations in 1999. From 1995 to 1998 river discharge did not seem to have a strong affect on timing of adult sucker catch rates in the lower Williamson River. However, in 1999 adult catches peaked just prior to the peak in the hydrograph.

It is likely that trammel net efficiency was reduced at higher discharge rates, underestimating the size of the spawning run during years when flows were higher. Mean April and May discharge rates were similar from 1995-1997, averaging about 2000 cfs per year, yet adult abundance values decreased steadily. Discharge rates increased substantially in 1998 and 1999 (2500-3000 cfs), and adult sucker catches continued to decline. In 2000, discharges were similar to 1995-1997 and catch rates were higher. This suggests that higher discharge rates may have contributed to underestimates of run size in 1998 and 1999. It may also indicate increased recruitment of first time spawners from the 1991 and 1993 year-classes.

Changes in weather patterns and the arrival of cold fronts seemed to reduce fish movements. Highest catch rates occurred during clear, warm weather. Fish distribution was often patchy, with significantly different catch rates among nets 100 m apart. Unlike the related cui-ui (*Chasmistes cujus*) in Pyramid Lake, Nevada (Scoppettone et al. 1986), large groups of suckers did not congregate for extended periods of time at the mouth of the Williamson River. Instead, small groups seemed to migrate upstream shortly after arrival.

Few migrants of either species appeared to occupy the upper part of the water column once in the river. Floating trammel nets fished near the mouth of the Williamson River captured less than 10% of the number of suckers captured in adjacent trammel nets fished on the bottom (Perkins et al. 2000a).

Caution should be used in interpretation of the lower Williamson River spawning abundance indices because 1) Lost River and shortnose suckers may vary in their vulnerability to capture in trammel nets, 2) only a proportion of each population occurs in the Williamson River in any given year and this proportion probably varies between species and among years , 3) residual use by non-spawning adults will over estimate the population and 4) spawned out fish returning to the lake made up a high percentage of the catch in at least one year (2000). Experience at Clear Lake Reservoir indicates that shortnose suckers are about twice as vulnerable as Lost River suckers to trammel nets, possibly due to different feeding behaviors. Whether vulnerability varies between the species during the spawning season is unknown. In 1999, substantial residual use in June and July by non-spawning suckers was documented in the lower Williamson River. This use may also occur during the spawning migration period.

4.4.1.3 Adult Sucker Population Estimates

In the spring of 1995, BRD tagged 60 Lost River suckers and 405 shortnose suckers in the lower Williamson River. Later that year a relatively large sucker die-off occurred and many fish were collected and checked for tags. From approximately 300 Lost River suckers and 100 shortnose suckers checked for tags, none were detected (BRD, unpublished data).

Of the 1,572 Lost River and 1,494 shortnose sucker adults that were collected from the 1996 fish kill and examined for identification tags, 3 Lost River and 10 shortnose suckers had tags present (BRD 1996). All three Lost River suckers and six of the shortnose suckers had been tagged in the Williamson or Sprague Rivers in spring 1996. These fish were used to estimate population sizes prior to the fish kill. The four additional tagged shortnose suckers had been tagged in previous years and were not appropriate for inclusion in the calculation of the population estimates. The number of marked fish included in the estimate calculations was 307 Lost River suckers and 1080 shortnose suckers. The 1996 Lost River and shortnose sucker population estimates were 94,093 (+/- 81,805; 95% confidence interval CI) and 252,181 (+/-173,813 95% CI) respectively (BRD, unpublished data).

In 1997, 511 Lost River suckers and 993 shortnose suckers from the 1997 die-off were examined for identification tags. Two Lost River suckers and 8 shortnose suckers had tags. The number of fish tagged in 1997 included 269 Lost River suckers and 1318 shortnose suckers. In 1997, the Lost River sucker population was estimated at 46,079 (+/-44,775 95% CI) and shortnose sucker population was estimated at 145,675 (+/-89,574 95% CI; BRD unpublished data).

The population estimate data are not appropriate to estimate survival estimates between years or to infer a specific decrease in the size of the populations. This data should be used with caution for the following reasons. One, many of the suckers collected from the die-offs were in a highly decomposed state and may have shed their tags. Two, the die-off fish may represent a biased group of fish with relatively few from the Williamson River spawning group. Three, the die-off may have been selective for age/size classes not well represented in the Williamson River where most of the tagging occurred. Four, the estimates are based on an assumption of no recruitment into the adult population. Five, the estimates assume that adults spawn every year and thus were available to tagging the spring before the fish kill.

4.4.1.4 Demographics - Williamson/Sprague River system

The demographics of the Williamson/Sprague River system sucker spawning populations appear to be much different in the late 1990's than during the mid-1980's. In 1984 and 1985, the spawning runs of Lost River and shortnose suckers in the Williamson and Sprague Rivers were composed primarily of large, presumably old fish, suggesting that both species had experienced an extended period of minimal adult recruitment (Bienz and Ziller 1987). Shifts towards smaller fish of both species in the late 1980's and again in the mid to late 1990's suggest the recruitment of younger year classes. Ageing data from fish collected in the 1995-1997 Upper Klamath Lake fish die-offs indicate that the majority of adult suckers were from the 1991 year-class. Recruits from the 1993 year-class may have started to appear in 1998 as indicated by a peak in the size distribution of male shortnose suckers (Perkins et al. 2000a). Young-of-year (age 0) assessments indicated relatively high numbers of Lost River and shortnose suckers were produced in 1991 and 1993 (Simon et al. 2000a).

Cohorts from 1991 and 1993 both correspond to years that had relatively good water quality in the summer relative to other recent years (Wood et al. 1996; Kann 1998). 1991 was a very dry year with relatively low lake levels while 1993 was a wet year with relatively high lake levels. Minimum lake levels in 1991 and 1993 were 4138.2 and 4139.5, respectively. The 1991 year-class also corresponds to a year in which the April discharge of the Williamson River was the second lowest on record (1920-1998), which could have benefited reproduction by minimizing egg loss from the substrate (Perkins et al. 2000a).

Size distribution of Lost River and shortnose suckers captured from the Williamson and Sprague Rivers from 1995-1996 were much different than those documented in the 1980's. Specifically, small Lost River suckers (400-500 mm FL) dominated the catch in 1995 and 1996 while larger fish were more abundant in the 1980's (600-700 mm FL) (Bienz and Ziller 1987, NBS 1996). Lost River suckers over 600 mm FL were rare in 1995 and 1996. Smaller shortnose sucker adults dominated the catch in the Williamson and Sprague rivers in 1995 and 1996 (300-400 mm FL). In 1982-1985, adults 400-500 mm FL were most numerous (Bienz and Ziller 1987).

In 1997 and 1998 there was a shift in the length frequency distribution to larger sizes for both Lost River and shortnose suckers compared to 1995 and 1996 (Perkins et al. 2000a). Most of the Lost River suckers were over 500 mm FL with a peak in size distribution of about 520 mm FL in 1997 and 540 in 1998. In 1999, it was difficult to see any length frequency trend since only 20 Lost River suckers were captured (Markle et al. 2000a). In 2000, most Lost River suckers ranged from 475-600 mm FL with a peak about 525 mm FL. There were fewer fish in the 400-500 mm FL range and >600 mm FL than 1995-1998 (R. Shively, BRD, per. com.).

The shortnose sucker peak size increased from about 320 mm FL in 1995, to 360 mm FL in 1996, and 380 mm FL in 1997. The 1998 shortnose sucker length frequency distribution was more like 1996. This shift back may have been affected by the 1997 fish die-off that was selective for larger fish (Perkins et al. 2000a). More shortnose suckers than Lost River suckers were collected in the 1997 die-off. Also, the 1993 year-class may have started to recruit into the adult spawning population affecting the size distribution. In 1999, smaller shortnose suckers (310-350 mm FL) dominated the catch suggesting that the 1993 year-class may be dominating the run. Shortnose suckers were mostly 325-425 mm FL in 2000 with a peak about 400 mm FL (Rip Shively, BRD, per. com.).

4.4.1.5 Demographics - Shoreline Spawning Areas

Sucker spawning has been monitored at Sucker Springs during many years between 1987 and 2000 (Perkins et al. 2000a; Shively et al. 2000a; R. Shively, BRD, per. com.). Since 1993, other springs on the east side of the lake including Silver Building, Barkley, Boulder, and Ouxy have been monitored occasionally. One non-spring shoreline spawning site (Cinder Flat) was monitored regularly in 1999 and 2000.

The size of Lost River suckers, and annual changes in size distribution, were noticeably different between fish from the springs and the Williamson/Sprague river system from 1987 to 1996. Lost River suckers at the springs were consistently larger than those in the rivers (Perkins et al. 2000a). The size distribution of fish at the springs did not change appreciably from 1987 through 1993, except for an influx of smaller males in 1993. However, starting in 1996, and becoming more noticeable in 1997 and 1998, the frequency of females larger than 700 mm FL began to decline dramatically (Perkins et al. 2000a, Shively et al. 2000a). Likewise, the frequency of males larger than 600 mm FL was much reduced in 1998-2000 compared to earlier years. Some of the decline in larger fish may have been due to annual fish kills from 1995-1997 that were selection for larger fish (Perkins et al. 2000b). Also gradual attrition of old fish may have occurred. An infusion of smaller males 475-575 mm FL was noted beginning in 1996 and continuing through 2000.

The average size of Lost River suckers captured at shoreline spawning areas generally decreased as the spawning season progressed (Perkins et al. 2000a, Shively et al. 2000a). It is possible that individual timing of Lost River sucker spawning is affected by size (age). Prior to 1999, the majority of sampling effort occurred before May 1. In 1999 and 2000, suckers were captured from March until early June. Therefore, sampling prior to 1999 may have been biased for larger older fish. Scoppettone et al. (1986) observed that smaller, younger cui-ui at Pyramid Lake spawned at the end of the spawning season.

From 1996 to 2000, the Lost River sucker sex ratios were dominated by males (Perkins et al. 2000a; Shively et al. 2000a; R. Shively, BRD, per. com.). This skewed ratio may be explained in part by male behavior to remain at the spawning areas longer than females making them more vulnerable to capture. Another possible explanation could be new recruitment from the 1991and 1993 year-classes. Perkins et al. (2000a) reported that male Lost River suckers migrating up the Williamson River begin to be recruited into the adult population starting at 4+, while females did not begin to mature until age 7+. These data were based on examining length frequency distributions and noting when fish from the 1991 year-class, which is presumed to be a strong year class, began showing up in trammel net catches. Fish from the 1991 year-class would have been 8+ in 1999. Buettner and Scoppettone (1990) examined opercles from Lost River suckers collected during the 1986 fish kill in UKL and reported that individuals matured between 6-14 years of age with the peak being age 9.

Shortnose sucker use of the shoreline springs appears to be much less than by Lost River suckers. Perkins et al. (2000a) only captured 67 and 26 shortnose suckers from springs in 1993 and 1996 respectively. In 1999 and 2000, 19 and 68 were captured during fairly intensive shoreline sampling (Shively et al. 2000a; R. Shively, BRD, per. com.). Numbers of Lost River suckers captured at the shoreline sites in 1993, 1996, 1999, and 2000 were 221, 164, 808, and 1,258 respectively. The larger catches in 1999 and 2000 were related to a substantially increased sampling effort than 1993 and 1996. The mean size of shortnose suckers was 360 mm FL in 1999 and 2000 that was slightly larger than previous years.

Historically, sucker spawning occurred at Barkley Springs, Odessa Springs, Harriman Springs, and other lake spring areas (USFWS 1993). Reclamation has made infrequent daytime visual observations at these locations during the spring months since 1993. No suckers have been observed. Visual observations and trammel net surveys have also been made at several shoreline springs on Bare Island, resulting in no spawning suckers (BRD 1997). Cinder Flat, a gravelly shoreline site with no discernable spring influence located north of Ouxy Springs was a newly monitored spawning location. This site was first reported by fishermen about 1995 and was sampled extensively in 1999 and 2000 by BRD.

From March 9 to June 7, 2000 BRD set trammel nets at 31 potential shoreline spawning sites with suitable substrate in the southern portion of the lake (R. Shively, BRD, per. com.). Sampling locations were selected based on potential suitability of shoreline substrate for sucker spawning. Most sites were sampled 5-10 times over the course of the field season. Two-hundred-sixty-eight suckers were captured with the majority of fish being captured in the Howard Bay or Modoc Point sites. Netting data did not indicate the presence of any spawning groups.

4.4.1.6 Other Spawning Locations

Reclamation monitored sucker spawning migrations from Agency Lake into the Wood River in 1996. Trammel nets were set overnight in Agency Lake near the Wood River mouth at 1-2 week intervals from March 1 to May 14. Twenty-seven shortnose suckers, 11 males and 16 females, and one female Lost River sucker were captured. On May 17, a boat electrofishing survey was conducted in the lower two miles of river. Eleven male shortnose suckers were captured in scattered locations.

In 1999, BRD infrequently monitored fish in Agency Lake near the mouth of the Wood River over nine days during spring using trammel nets (R. Shively, BRD, per. com.). Forty-six suckers were captured including 32 shortnose suckers, 2 Lost River suckers and 12 intermediate forms (possibly Klamath largescale sucker hybrids). One shortnose sucker tagged in 1996 at the mouth of the Wood River was recaptured as well as three Klamath largescale suckers tagged at the Sprague River Dam (R. Shively, BRD per. com.). In 2000, 9 suckers were sampled from 10 sampling efforts. Six fish were shortnose suckers, 1 Lost River sucker, 1 Klamath largescale sucker and 1 sucker hybrid. In 1999, trammel nets were fished overnight (8 hour sets) while in 2000 nets were fished during the daytime for 2-4 hours.

Historically, sucker spawning occurred in other Upper Klamath Lake tributaries including Crooked Creek, Fort Creek, Sevenmile Creek, Fourmile Creek, Odessa Creek, and Crystal Creek (Stine 1982). Although no rigorous spawning run surveys have been conducted in these locations, infrequent visual, electrofishing, trap and trammel net surveys have been conducted by Reclamation, BRD, Klamath Tribes, ODFW, Cell Tech, and OSU over the last decade. There were no documented evidence of sucker spawning runs in these streams.

4.4.1.7 Larval Emigration - Williamson River

Intensive larval sucker emigration studies were conducted during 1987, 1988, and 1989 in the lower Williamson River (Buettner and Scoppettone 1990; Klamath Tribes 1996). Estimated total numbers of emigrating sucker larvae at River Kilometer (rkm) 9.8 were 14, 35, and 73 million for 1987, 1988, and 1989 respectively. In 1989, an additional estimate of the number of emigrating larvae entering Upper Klamath Lake was made. Surprisingly only 4.9 million were estimated at rkm 0.1 from May 1-June 28.

Timing of larval emigration was assessed during four years using drift nets (1987 and 1988 - Buettner and Scoppettone 1990; 1989 - Klamath Tribes 1996; and 1998 - Markle et al. 2000a). Date of first sucker larvae capture for all years was during the first week of May. However, during 1989 substantial numbers of suckers were captured on the first sample day. Peak emigration in the lower Williamson River was as early as mid-May (1987) to as late as mid-June (1998). Substantial numbers of larvae were captured from mid-May to mid-June during all four years. Larval drift was very low by the sampling ending dates that ranged from June 28 to July 15.

In 1998, OSU monitored larval emigration at the Modoc Point Road bridge on the lower Williamson River (rkm 8). Larval drift sampling began on May 5 and larval suckers were first captured on May 17. However, sucker larvae were first observed in the lower Williamson on May 5, 1998 (Cooperman and Markle 2000). The last larval sucker captured in the drift net was July 15. Two peaks in larval abundance were documented, at the end of May and middle of June (Markle et al. 2000a). This compares to peak emigration in 1987-1989 ranging from early May to mid-June (Buettner and Scoppettone 1990; Klamath Tribes 1996).

In 1998, larval sucker movement through the lower Williamson River, as measured by density of larval suckers in drift samples, was largely restricted to 2100-0500 hr with a peak about 0300 hr (Cooperman and Markle 2000). This corresponds closely with diel sampling by Buettner and Scoppettone (1990). Larvae appear to move to the river margins during the day (Klamath Tribes 1996).

All three developmental stages of sucker larvae (protolarvae, mesolarvae, and metalarvae; Snyder and Muth 1988 as cited by the Klamath Tribes 1996) were observed in the Williamson River in 1989 (Klamath Tribes 1996). Each developmental stage lasts about 2-4 weeks. Sucker larvae from mid-May at rkm 9.8 were about 63% protolarvae and 37% flexion mesolarvae while in mid-June protolarvae and flexion mesolarvae were 25% and 75% respectively. Most of the larvae entering the lake in 1989 were flexion mesolarvae (early development stage of mesolarvae), while a small proportion of the emigrating larvae had taken up residence near the river mouth and had developed into postflexion mesolarvae (late development stage of mesolarvae) by mid-June. On June 8 and June 15-16 1995, mostly flexion mesolarvae (11-13mm TL) were collected from pop net samples at rkm 0.7 on the Williamson River. On July 21, approximately 20%, 50%, and 30% were flexion mesolarvae, postflexion mesolarvae, and metalarvae, respectively.

In 1998, 83% of the larvae captured in drift net samples at Modoc Point Road bridge were protolarvae and 17% flexion mesolarvae (Cooperman and Markle 2000). In the lower Williamson River near the mouth 49% were protolarvae and 51% flexion mesolarvae. No post-flexion mesolarvae or metalarvae were collected in drift net samples at the Modoc Point Bridge. Very few were captured in pop net sampling near the mouth.

The Klamath Tribes monitored wind direction and strength in 1989, and found that wind influenced the cross sectional distribution of larvae at the water's surface near the mouth of the Williamson River (Klamath Tribes 1996). On nights when the wind was blowing parallel to the channel, larvae were symmetrically distributed across the channel with the most in the middle and the fewest on the edges. However, when the wind was strong and blowing to the east, perpendicular to the channel, larval distributions were strongly skewed to the eastern channel and shoreline. It is likely, therefore, that wind influences larvae movements and distribution in Upper Klamath Lake.

Larval fish need to begin feeding before they exhaust their yolk. It has been shown for other species that larval survival, and subsequent year class strength, can be determined by the availability of suitable food during this critical period (Crecco et al. 1983 as cited by Klamath Tribes 1996). Yolk reserves are gone or nearly so by the time the Lost River and shortnose suckers become flexion mesolarvae. Gut fullness was evaluated on sucker larvae to determine whether they were finding adequate food in the lower Williamson River before entering the lake. In 1989, frequency of full guts was substantially higher in mid-June than mid-May at rkm 0.1 (Klamath Tribes 1996). Twenty-five percent had empty guts in May while almost none were empty in mid-June. In 1995, 76% and 88% of larval suckers collected at rkm 0.7 had empty guts on June 8 and June 15-16 respectively (Klamath Tribes unpublished data).

In 1998, larvae from drift samples in the river seldom had food in the gut particularly larvae from Modoc Point bridge (Cooperman and Markle 2000). At the lower Williamson River station only 3% had food during May 25-29 compared to 16% during June 15-19 and gut fullness was mostly rated low for fish with food. Most of the larvae captured from daytime pop netting in the Williamson River had empty or low gut fullness indices compared to mostly medium to high gut fullness in lake-captured fish (Cooperman and Markle 2000). Flexion larvae, across river and lake zones shows a dramatic difference in gut fullness with the lake-caught larvae much more likely to have food in the gut.

It is suspected that larval suckers subsist mainly on zooplankton, and that larval survival is likely influenced by the degree of coincidence between zooplankton bloom formation and larval entry into nursery areas (Klamath Tribes 1996). High densities of larval suckers may not be able to rear in the lower Williamson River until food production increases, which may explain why postflexion mesolarvae were virtually absent at rkm 0.1 in May, but were present in June in 1989. In 1995, post-flexion mesolarvae and metalarvae were absent from June samples but present in July (Klamath Tribes, unpublished data). Littoral macrophytes may support a more diverse assemblage of small-bodied zooplankters, those that would be useable as food for larval suckers, than open water areas (Wetzel 1983 as cited by Klamath Tribes 1996). This may be one reason for the disproportionate use of the emergent vegetation zone by sucker larvae.

The Klamath Tribes conducted a study in 1999 to assess the effects of starvation on larval sucker growth and survival (Klamath Tribes, unpublished data). Results are preliminary, but so far show that a three day delay in the onset of feeding (compared with no delay) results in 1) a statistically significant decrease in burst swimming distance, suggesting a decreased ability to avoid predators; and 2) a statistically significant decrease in body depth, a reflection of slow or no growth. After a feeding delay of 6 days, body depth differences were exacerbated between feeding and starving larvae, burst swimming distances of starved larvae were almost half those of fed larvae, and dry weights were significantly lower for starving larvae. After a 9 day feeding delay, a broad array of starvation effects were observed (all statistically significant differences between fed and starved larvae): body depths and lengths were smaller, eye diameters were smaller, there were fewer rays developing in the caudal (tail) fins, dry weights were lower, and burst swimming distances were lower. Basically, larvae were showing the effects of starvation after 3 days, and after 6-9 days they were obviously doing very poorly. The combined effects of decreased visual capability (eye diameter) and locomotory capability (fewer caudal rays and low burst swimming distances) likely translates into decreased foraging capability and increased predatory mortality, resulting in lower survival rates.

Investigators have consistently observed that sucker larvae in the lower Williamson River do not seem to find adequate food resources (as shown by high incidence of nearly empty guts). Major morphological changes to the river channel which accompanied development of the area likely led to slower emigration rates for sucker larvae through the lower river system into their nursery habitats in UKL. This emigration delay in habitats that appear to provide inadequate food resources may be increasing mortality of sucker larvae. Therefore, an important component of restoration activities in the Williamson River delta involves a return of the river channel to an appropriate geometry, which will facilitate larval transport into UKL nursery habitats. Efforts are currently underway by the Nature Conservancy to restore the historic form and function of the lower Williamson River delta.

4.4.1.8 Larval Ecology

OSU systematically monitored larval sucker distribution and relative abundance in Upper Klamath Lake from 1995-1999 using larval trawl methods (Simon et al. 2000a). Larval suckers were first captured in late April during most years, peak catches occurred in June and densities dropped to very low levels by late July.

Sucker larvae have been observed in Upper Klamath Lake at Sucker Springs as early as April 1 (Mark Buettner, Reclamation, personal observation.). Simon et al. (1996) observed substantial numbers of larvae on April 4, 1995 during shoreline searches. Essentially all sucker larvae have transformed to juveniles by the end of July (Simon et al. 2000a).

Larval suckers were distributed throughout Upper Klamath and Agency Lakes from 1995-1999 (Simon et al. 2000a). Catch rates were usually highest at the mouth of the Williamson River or Goose Bay. They were also relatively high near Hagelstein Park in most years. Other sites that occasionally had high numbers include Howard Bay (1996), Ball Bay (1999) and Stone House (1999). Very low catch rates were obtained in Agency Lake from 1995-1999.

Cooperman and Markle (2000) documented substantial numbers of sucker larvae in the area west of the Williamson River mouth. It was previously assumed that few larvae occurred in this area because the Williamson River typically flows east towards Goose Bay. In fact, pop net catches were several times higher for this site than Goose Bay in June 1998.

In 1998, OSU documented that sucker larvae in pop net samples were much more abundant in non-woody vegetation (emergent and submergent macrophytes) than in woody vegetation (willows) and unvegetated areas (Cooperman and Markle 2000). Woody vegetation and unvegetated sites had similar densities. Also there was no significant difference in numbers of suckers caught in Sparganium (burreed) and Scirpus (bulrush) vegetation types.

The importance of bottom substrate for sucker larvae is unknown. Most sites where sucker larvae are found have sand or gravel/cobble substrates. However, substrate along the Tulana shoreline west of the Williamson River where high densities of larvae have been found is mostly peat. Since larval suckers are mostly distributed in the upper part of the water column (Buettner and Scoppettone 1990) substrate may not be a very important habitat parameter.

Water quality associated with larval sucker distributions were monitored in 1996 by OSU during larval fish trawling. Similar to 1995, larval suckers were found in pH ranging from 7 to 10 (OSU, unpublished data). Substantial numbers of larvae were sampled at pH from 7.7-9.6. Distribution of pH values where fish were found paralleled the distributions at all sampling sites. However, a few sites were sampled with pH of 10.2 where no sucker larvae were found.

Larval suckers were captured at DO concentrations ranging from 4.5-12.5 mg/l with most occurring at sites with DOs from 5.5-10.5 mg/l (OSU, unpublished data). These results are similar to those documented in 1995 (Reclamation 1996). No sucker larvae were sampled at the few sample sites where DOs were 3.5 mg/l. With this exception, distribution of DO values where fish were found paralleled the distribution at all sampling sites.

4.4.1.9 Age 0 Sucker Recruitment

Since 1995, larval trawl catch rates have been substantial every year except 1998 (Simon et al. 2000a). Mean larval trawl catch rates in 1999 were higher than any year since 1995. The proportion of positive catches (catches >0) was

51, 53, 44, 36, and 43% for 1995-1999 respectively. The proportion of large catches (>100) was 5% in 1999, much higher than 1997 or 1998, slightly higher than 1995, but lower than 1996. Although one larval survey was high in 1997, it did not persist as catches dropped by the next survey and catches with all gears remained low throughout the year. High levels of un-ionized ammonia that year may have inflicted high mortality on larvae (Simon et al. 1988). There was no correlation among adult spawning run indices (Markle et al. 2000a) and larval indices from 1995-1999.

Age 0 suckers, as indexed by beach seine catch rates, were also abundant in Upper Klamath Lake in 1999. Catches were lower than those from 1996, but higher or much higher than other years. The proportion of positive catches (>0) in 1999 was similar to 1995 and lower than 1996, but much higher than 1997 and 1998. Similarly, the proportion of large catches (>25) was similar to 1995 and lower than 1996, but much higher than in 1997 and 1998. These data all suggest juvenile abundance in late June through August as measured by beach seine sampling was higher in 1999 than 1997 and 1998, similar to 1995 but lower than 1996. There was little correlation (r=0.22) among adult spawning run indices and beach seine indices from 1995-1999, but there was a much stronger correlation (r=0.77) between larval trawl and beach seine indices.

Based on shoreline cast net surveys, mean shoreline abundance for Lost River suckers was higher in 1999 than 1995-1997, but similar to 1998, while mean shoreline abundances for shortnose suckers was higher in 1999 than 1997 but similar to 1995, 1996, and 1998 (Simon et al. 2000a). Other indices suggest near-shore abundance was highest in 1999 compared to previous years. The proportion of positive catches (>0), and the proportion of large catches (>5 and >10) were all higher in 1999 than 1995-1998. In 1999, 43% were Lost River suckers and 57% shortnose suckers.

Otter trawl catches in late summer/fall were much higher in 1999 than any other year. The total number of age 0 suckers captured during this survey (168) exceeded the total of 60 age 0 suckers captured in all random trawl surveys from 1995-1998. Of these 60, 37 were caught in 1995 and only 23 from 1996-1998. Of 186 age 0 suckers caught otter trawling 156 (84%) were Lost River suckers and 30 (16%) were shortnose suckers.

The mean whole-lake population estimate for age 0 Lost River sucker in 1999 (300,000) was the highest since 1995. Mean whole-lake population estimate for age 0 shortnose sucker in 1999 was also the highest, but only slightly higher than 1995, 1996, and 1998. These estimates, along with larval trawl, and beach seine data, suggest that age 0 suckers in 1999 were substantially more abundant than in 1997 or 1998, and at least or more abundant than 1995-1996. Caution should be used in interpreting the 1998 cast net data as these numbers are probably inflated from a single sample in which an inordinately large number (1168) of suckers were caught. Without this sample, cast net abundance data are similar to 1997. Larval trawl and beach seine data from 1998 are also similar to that of 1997, and suggest that these two years probably represent poor recruitment. The data suggests 1999 was a good year for sucker recruitment.

During the period 1995-1998, larval and juvenile sucker abundance generally declined (Simon et al. 2000a). During this same period, adult spawning run indices of both Lost River and shortnose suckers also declined (Markle et al. 2000a). Adult spawning run indices continued to decline in 1999 (Markle et al. 2000a), however, larval and juvenile numbers reversed their declining trends and were abundant in 1999, suggesting a poor stock-recruitment relationship (poor correlation between adult spawning population and young fish produced). However, the degraded habitats and poor lake water quality introduce an even greater degree of uncertainty into the stock-recruitment relationship.

In all years, age 0 Lost River and shortnose sucker population estimates in September and October were less than August. This consistent annual trend of sharply decreasing age 0 sucker numbers in late summer and fall remains a concern. It is suspected that this can be partially explained by a shift in habitat from shoreline to offshore areas (Simon et al. 1996). However, OSU excluded vegetated habitats from their late season sampling designs. It is possible that significant numbers of juvenile suckers were residing in un-sampled vegetated habitats during years with relatively high lake levels. Preliminary work by BRD in 2000 shows that more work needs to be done to ascertain the importance of shoreline habitats to juveniles.

Spatial and temporal distribution of juvenile suckers in Upper Klamath Lake has been studied through an intensive systematic monitoring program during the summer and fall from 1995-1999 (Simon et al. 2000a). Juvenile suckers were collected from fixed sites throughout Upper Klamath Lake using beach seines, cast nets, and otter trawls.

Consistently high beach seine catch rates were documented for the mouth of the Williamson River, Goose Bay, and Modoc Point for most years. High densities were noted at Howard Bay (1996) and Hagelstein Park and Stone House (1999). Beach seine catches were very low in Agency Lake and most stations on the west side of Upper Klamath Lake. Catches at these locations were primarily shortnose suckers.

Stratified random cast net sampling showed three major areas of age 0 sucker concentration in Upper Klamath Lake; the south end of the lake, an area primarily south of Buck Island; the eastern shoreline from Modoc Point to Hagelstein Park; and the Shoalwater Bay/Ball Bay region in 1997 (Simon et al. 2000a).

Relative importance of emergent vegetation habitat for juvenile suckers has not been quantified. Juvenile sucker monitoring by OSU focused on mostly unvegetated locations because of sampling difficulties associated with vegetated areas. However, the Klamath Tribes have observed age 0 juvenile suckers in emergent vegetation along the lower Williamson River and Goose Bay (L. Dunsmoor, Klamath Tribes, per. com.). BRD conducted trap net surveys near Goose Bay in emergent vegetation and adjacent unvegetated areas during summer 2000. Catch rates were generally equal to or greater in the vegetated versus unvegetated sites (R. Shively, BRD, per. com.). No information is available on distribution of juvenile suckers in extensive stands of emergent vegetation at Hanks Marsh and Upper Klamath Marsh. However, OSU captured very few juvenile suckers adjacent to shoreline marsh habitats of the northern margin of Upper Klamath Lake, and along the marsh at Squaw Point, Shoalwater Bay, and Hanks Marsh (Simon et al. 2000).

Bottom substrate type has been identified as an important habitat feature for age 0 juvenile suckers found along the shoreline (Simon et al. 2000a). From 1995-1999, age 0 sampling was based on random monitoring of specific habitat types to provide habitat-specific densities. Highest age 0 sucker densities were found on small mix and gravels and lowest densities were found on fines, sand, and boulders (Simon et al. 2000a). The low catches over boulder substrates may be associated with poor sampling efficiency using cast nets. Diverse substrate types are found mostly in the shoreline areas (<10 m from high-water mark). Fine particle (muck) substrates occupy the vast majority of the offshore areas. Shoreline substrate area changes with changes in lake level have not been quantified.

Water quality associated with age 0 suckers has been monitored annually since 1994 (Simon et al. 1995, 1996; OSU, unpublished data). Distribution of dissolved oxygen and pH for all samples and those samples containing suckers from beach seine, cast net and otter trawls have been generally similar, indicating no obvious preference or avoidance of certain water quality conditions.

4.4.1.10 Larval Sucker Entrainment – A-Canal and Link River Dam

Larval fish entrainment into the A-Canal was evaluated in 1990, 1991, and 1996-1998 (Harris and Markle 1991, Markle and Simon 1993, Gutermuth et al. 1997, 1998b; Natural Resource Scientists, unpublished data). Entrainment was monitored at the A-Canal headworks in 1990, 1991, and 1998. During 1996 and 1997 monitoring took place at the split of the B-Canal and C-Canal, 8.6 miles into the canal system. It is probable that some of the A-Canal entrained suckers did not reach the B-C sampling site because of other diversions and fish occupying the A-Canal as habitat. Although three different entities were involved in the entrainment studies, standardization of methods and gear were employed as much as possible. However, fish sampling techniques at the C-canal harvest site were substantially different than the drift net sampling performed in the A-Canal.

Larval entrainment estimates for 1990 were 422,000 (0-1,124,000=95% CI). We suspect larval entrainment was greatly underestimated because sampling began after much of the entrainment was suspected to occur. Also no nighttime monitoring occurred. Larval sucker movement appears to be higher during darkness than daylight (Gutermuth et al. 1998b). In 1991, it was estimated that 759,000 sucker larvae were entrained into the A-Canal (204,000-1,422,000=95% CI)(Markle and Simon 1993). The 1996 and 1997 entrainment estimate for larval and early juvenile suckers was 3,262,000 (1,281,000-5,426,000=95% CI; Gutermuth et al. 1997) and 1,683,000 (749,000-2,869,000 = 95%CI; Gutermuth et al. 1998b) respectively. Larval entrainment results from 1998 have not been reported.

Timing of larval drift into the A-Canal and nearby Link River Dam diversion canals was similar. Larval suckers were collected as early as April 28 on the Eastside diversion canal. The earliest A-Canal date was May 19, 1997 that was also the first day sampled. We suspect that the beginning of larval sucker entrainment was missed in 1990, 1996, and 1997 due to a late start date for sampling. In 1991, the first larval sucker was collected on May 21 although sampling began April 7. Low densities of sucker larvae may have gone undetected due to the sub-sampling protocol. Peak larval sucker entrainment occurred during June for the A-Canal and Link River Dam locations. In 1990 and 1991 substantial numbers of larval suckers were also documented in early July. Ending date for larval sucker entrainment generally occurred in mid to late July. However, in 1996 larvae were captured as late as August 11.

The highest density of drifting sucker larvae occurred during the early morning hours (0000-0800) at the Eastside and Westside diversion canals, followed by evening and daytime (Gutermuth et al. 1999). This same pattern was monitored in the A-Canal in 1996. Diel patterns of drift were not obvious for 1991 and 1997 in the A-Canal. Movement patterns in the canals are similar to the Williamson River where migration occurs primarily at night or during early morning hours (Buettner and Scoppettone 1990, Klamath Tribes 1996).

The greatest density of canal drift was usually associated with the surface stratum (Harris and Markle 1991; Gutermuth et al. 1998b). This pattern of distribution was also documented for sucker larvae in the lower Williamson River (Buettner and Scoppettone 1990; Klamath Tribes 1996).

The relationship between the lunar cycle and sucker abundance was not clear from the Eastside and Westside larval sucker abundance data. However, data from the A-Canal in 1990 (Harris and Markle 1991), 1991 (Markle and Simon 1993), and 1997 (Gutermuth et al. 1998b) saw peaks in the abundance of larval suckers coinciding with the full moon. In 1996, highest abundance of larval suckers occurred shortly after a new moon and the second peak during the full moon.

4.4.1.11 Juvenile and Adult Sucker Entrainment – A-Canal and Link River Dam

New Earth monitored larger fish (> 75mm) that were found on their debris reduction screens and on algae harvest screens in 1996 (Gutermuth et al. 1997). One-hundred-fifty-seven suckers were collected off the debris screens and 140 off the harvest screens. Many of these fish were probably dead before they reached the screens. During August and September substantial numbers of large juvenile and adult suckers were collected at the headworks of the A-Canal associated with a die-off in Upper Klamath Lake. Also, low dissolved oxygen conditions in the A-Canal during August apparently led to a fish die-off within the canal.

A trap net was also fished in the B-Canal just downstream from the algae harvest site. Two-hundred-fifty-seven juvenile and adult suckers were captured between June 24 and October 20. These fish represented a relative abundance of age 0, early juvenile, and older suckers. Many of these fish were found dead in the trap net. It was suspected that most of the dead fish had died in the canal and drifted into the net.

In 1997, only 11 suckers were caught in the trap net and age 0 suckers were extremely rare. It is likely that some suckers were missed when not sampling during the poorest water quality period (e.g., several weeks in August). A total of 90 suckers were captured on the debris reduction screens and on the algae harvest screens in 1997. It is difficult to evaluate the juvenile and adult sucker data from the Cell Tech harvest facility because entrainment rates were primarily dependent on poor water quality and the collection of stressed and dying fish.

Studies designed specifically to quantify juvenile and adult sucker entrainment into the A-Canal were conducted in 1997 and 1998 (Gutermuth et al. 2000a). Since researchers were unable to calibrate fish trapping operations through mark/recapture techniques, fish catches were extrapolated based on percent of daily flow sampled to develop entrainment indices that accounted for un-sampled volumes of water and periods of time. The total 1997 A-Canal entrainment index was estimated at 465,536 fish of all species and included 46,708 suckers. The 1998 entrainment index was 1,239,801 total fish and included 246,524 suckers. The sucker catch was substantially higher in 1998, largely due to an increase in age 0 collections. For both years, the majority of suckers were caught in August (76% in 1997 and 68% in 1998), however, numerous suckers were collected in September 1998 (25%). The larger 1998 entrainment index may be associated with a stronger year class than in 1997 or increased entrainment related to poor water quality.

In August-September 1997 entrainment rates of large fish (>150 mm) were primarily the result of stressed and debilitated fish moving from severely degraded water quality conditions in Upper Klamath Lake during a fish kill.

Numerous age 0 fish in relatively good condition, were also collected at that time. These fish were likely stressed by poor water quality conditions, but may also have been moving in response to other stimuli (e.g., competitive interactions, attraction to flows, temperature, etc.). Consequently, the increased late-summer catches may, when combined with similar 1998 patterns, suggest an annual movement pattern.

The higher entrainment rates of age 0 suckers in the A-Canal during late summer of 1998, as contrasted to 1997, corresponded to that years higher late-summer A-Canal and total south lake outflows. These data may suggest that if passive dispersal of age 0 suckers occurs, higher lake outflows in late summer would expose more suckers to the vicinity of the A-Canal headworks. Both 1997 and 1998 were wetter than average years where the level of Upper Klamath Lake was maintained at a high level (>4140 feet). It is possible that higher entrainment rates may occur during dryer years because irrigation releases during late summer are usually high and shallow shoreline habitats that support age 0 suckers are reduced (Gutermuth et al. 2000a).

Fish entrainment studies were conducted at the two diversions (Eastside and Westside) on Link River Dam in 1997, 1998, and 1999 (Gutermuth et al. 1999, 2000b). Although sampling methods were different from those employed at the A-Canal, entrainment results were similar. Sucker entrainment was most common in August and September. Higher entrainment rates occurred after the A-Canal was shut down.

Reclamation has conducted salvage operations from Klamath Project canals receiving water from Upper Klamath Lake yearly since 1991. A summary of results from 1991-1995 was presented in the 1996 BA (Reclamation 1996a). Between 1996 and 1999, the numbers of suckers salvaged were 11,166 (1996), 2,383 (1997), 2,717 (1998), and 26,928 (1999; Reclamation 2000b). Age 0 fish dominated the 1996, 1998 and 1999 salvage operations and age 1+ in 1997. The relatively high numbers salvaged in 1996 and 1999 may be indicative of strong year classes in Upper Klamath Lake.

Numbers of suckers salvaged from Klamath Project canals do not appear to be strongly correlated with age 0 sucker monitoring data in Upper Klamath Lake (Simon et al. 2000a) or the fish entrainment data collected at the A-Canal headworks or Link River Dam diversion (Gutermuth et al. 2000a, 200b). The canal salvage data should probably be viewed as a qualitative index, since there are several factors that influence the numbers salvaged. Poor water quality conditions have been documented in several years that likely resulted in high mortality of canal fish (Gutermuth et al. 1998b). Rates of sucker entrainment may also be related to habitat conditions on Upper Klamath Lake. During years with poor water quality (1996) higher numbers may move out of the lake than years with good water quality (1991, 1999). Varying levels of success in draining the canals and guiding suckers out of the canals into the Lost and Klamath Rivers may also affect the results. Additionally, only a small percentage of the canal system is sampled and some fish are undoubtedly missed. Locations where concentrations of suckers are found vary from year to year and new sites with fish are found each year.

4.4.1.12 Fathead Minnow Predation

Exotic fathead minnows (*Pimephales promelas)* were first reported from Upper Klamath Lake in 1979 (J. Ziller, ODFW, per. com.). By the mid-1980s the population had exploded (Bienz and Ziller 1987) and became the most abundant fish in Upper Klamath Lake. Concern about the potential impacts of the fathead minnow on sucker larvae prompted The Klamath Tribes to assess their predatory capabilities (Klamath Tribes 1995). They conducted lab research employing a two-factor analysis of variance experimental design in which water depth and vegetative structure were factors. Experiments were conducted in 1.07 m X 1.07 m X 0.7 m tanks with water depths of 0.3m and 0.6m. Repeated trials were conducted using a range of ages of both Lost River and shortnose sucker larvae.

Water depth significantly influenced survival rates in all five trials with shortnose suckers, and in four of seven trials with Lost River suckers (Klamath Tribes 1995). Presence of vegetation structure significantly influenced survival rates in none of the trials with shortnose suckers and in two of seven trials with Lost River suckers. Interaction of depth and structure factors was not significant in any of the trials. Although survival of sucker larvae in shallow water treatments without structure was not always deemed significantly lower than in treatments with structure, survival of larvae younger than 35 days in shallow water treatments without structure was always significantly lower than in deep water treatments (regardless of the presence or absence of structure). The Tribes submits that as water depth increases to about 0.6 m, the surface orientation of the sucker larvae and the bottom orientation of the fathead minnows results in enough separation to almost eliminate predation, even when the fathead minnows are hungry.

When considering the potential outcome of predatory interactions between larval suckers and other predators like largemouth bass, yellow perch, pumpkinseed sunfish and native sculpins and chubs, there is no assurance that a similar depth effect will be operative. Non-native bass and pumpkinseed are rare in UKL litoral regions, whereas sculpins are abundant. Sculpins are benthic ambush predators, and so the depth effects on predatory interactions between sucker larvae and sculpins will very likely be similar to those described in Tribes research. However, decreased predatory efficiency in structurally complex habitats has been documented in the literature for these and closely related species (Savino and Stein 1982, and Heck and Crowder 1991 as cited by Klamath Tribes 1996).

As sucker larvae grew they became less vulnerable to predation by fathead minnows, and the pattern of decreasing vulnerability differed by species, depth, and structure. Size-related survival of sucker larvae in deep water treatments differed by species: shortnose suckers larger than 12.5 mm were seldom eaten, while Lost River suckers larger than 11 mm were seldom eaten (Klamath Tribes 1996). In contrast, median survival rates were near 50% for shortnose suckers 13.0-13.2 mm and 30% for Lost River suckers 13.0 mm long in the 0.3 m depth without structure. Their study did not use shortnose larvae larger than 13.2 mm, but showed that fatheads could still prey on Lost River larvae 17 mm long.

4.4.1.13 Larval and Juvenile Sucker Bioassays

Acute bioassay research has been done on both Lost River and shortnose suckers to quantify levels leading to mortality of 50% of the fish over 96 hours (LC-50) for high temperature, low dissolved oxygen, high un-ionized ammonia, and high pH. Studies yielded variable LC-50 values for different species and life stages (Monda and Saiki 1993, 1994; Bellerud and Saiki 1995; Saiki et al. 1999). Falter and Cech (1991) measured a critical pH maximum for juvenile shortnose sucker of 9.55. This study subjected fish to constant pH increases of 0.025-0.030 pH units per minute with the critical maximum being the value at which fish loses equilibrium. *In situ* live cage studies were conducted with juvenile (age 0) Lost River suckers in 1995 (Martin 1997, Martin and Saiki 1999). Hatchery-reared fish were held for one week at various locations in the lake during the summer. Survival was correlated to water quality parameters collected at each location with a Hydrolab Datasonde II instrument. Chronic toxicity of low dissolved oxygen, elevated pH, and elevated ammonia concentrations of larval and juvenile Lost River suckers was studied by the University of Wyoming (Meyer et al. 2000).

The mean LC-50 values for the 96 hour bioassays for Lost River and shortnose suckers varied among species and life stages as follows: for pH 10.30-10.39; for un-ionized ammonia, 0.48-1.06 mg/l; for temperature, 30.35-31.82 C; and for dissolved oxygen, 1.34-2.10 mg/l (Saiki et al. 1999). Comparison of 95% confidence limits indicated that, on average, the 96 hour LC-50s were not significantly different from those computed for shorter exposure times (i.e., 24 hr, 48 hr, and 72 hr). LC-50s for the four water quality variables did not vary significantly between species. In general, larvae were more sensitive than juveniles to high pH and low dissolved oxygen concentrations.

Compared to field measurements of pH, ammonia, temperature, and dissolved oxygen, the bioassay data suggest that ambient summertime water quality conditions in Upper Klamath Lake can be acutely lethal to suckers. However, results from the acute bioassays should be viewed cautiously for the following reasons:

1) Test animals used were the progeny of matings from relatively few wild-caught fish. The data generated from these test animals might not adequately reflect species-wide responses to experimental conditions.
2) Results were based on test animals acclimated to presumably optimal water quality conditions whereas fish are highly adaptable and can often tolerate much harsher conditions if allowed to gradually acclimate to stressful limits.
3) Results are based on constant water quality conditions whereas in the field water quality variables fluctuate diurnally and interaction of two or more parameters can take place.
4) Quality of the test animals especially juveniles during some tests exhibited evidence of nutritional deficiency and disease and therefore might represent a conservative result.
5) Test animals were fed to satiation prior to testing; whereas fish in the wild may suffer the lingering effects of food deprivation after emigrating through the lower Williamson River which could decrease their ability to withstand reported LC-50 values.
6) More conservative and protective values may be defined by the lower (for pH, temperature, and ammonia) and upper (for DO) 95% confidence interval for the LC-50 values.
7) Chronic tests on a longer time scale would more realistically simulate the actual exposure regimes that suckers experience seasonally and over the course of diel changes during heavy algal blooms of *Aphanizomenon flos-aquae*.

Field studies with caged juvenile Lost River suckers were implemented to determine if fish mortalities resulted from degraded water quality conditions associated with seasonal blooms of phytoplankton, especially *Aphanizomenon flos-aquae* (Martin and Saiki 1999). Results indicated that fish mortality did not always increase as temperature, pH, and un-ionized ammonia concentration increased in Upper Klamath Lake. Little or no mortality occurred when these water quality variables attained their maximum values. On the other hand, an inverse relationship existed between fish mortality and dissolved oxygen concentration. High mortality (>90%) occurred whenever dissolved oxygen concentrations decreased to 1.05 mg/l, whereas mortality was usually low (<10%) when dissolved oxygen concentrations equaled or exceeded 1.58 mg/l.

Five chronic toxicity tests (14- or 30-day) were conducted with larval and juvenile Lost River suckers exposed to low dissolved oxygen concentrations, elevated pH, elevated ammonia, and a 14 day exposure to sub-lethal ammonia concentrations followed by exposure to sub-lethal DO concentrations (Meyer et al. 2000). Mortality threshold ranges determined in the toxicity tests were between about 1.5 and 2.0 mg/l in the DO tests, >10 in the pH test, and between 0.37 and 0.69 mg/l in the un-ionized ammonia tests. Contrary to the common expectation for fish chronically exposed to toxicants, Lost River suckers generally did not display sub-lethal responses to low DO concentrations, elevated pH, or elevated ammonia concentrations based on the three traditional chronic-toxicity endpoints used (growth, whole-body ion content, and swimming performance). In the 14-day sub-lethal ammonia/14-day sub-lethal DO test, mortality did not increase significantly and no sub-lethal effects were observed. It appears that, within the resolution of the traditional chronic-toxicity endpoints used, Lost River suckers essentially had to be dying before an adverse functional effect of the toxicant could be identified.

On the other hand, gill histopathology was sometimes more sensitive than the three traditional chronic endpoints. In the ammonia test, statistically significant structural changes occurred in gills of larvae exposed continuously to un-ionized ammonia concentrations 3.5 times lower than the lowest concentration at which significant mortality and growth effects occurred. Changes in gill structure that were quantified included significantly increased oxygen diffusion distance and increased thickness of secondary lamellae—the primary site for respiratory and ionoregulatory exchange in a fish. Additionally, qualitative structural changes were observed, including increased number of chloride and mucous cells, the appearance of mitotic figures, and infiltration of white blood cells into the lymphatic space. However, no statistically significant structural changes were detected in gills of fish exposed to the highest pH (10.0).

Body size and water temperature affect the critical swimming speed of juvenile Lost River suckers. Early juveniles (36-64 mm) had an average critical swimming speed of about 20 cm/s at 10 C and 25 cm/s at 25 C. Later juveniles (60-96 mm) had an average critical swimming speed of about 25 cm/s and 30 cm/s at 25 C. This information has important ramifications for developing fish screen criteria for Klamath Project diversions.

Another toxicity test was performed to determine the effects of the bacterium, *Flavobacterium columnare*, on Lost River sucker juveniles following 30-day sub-lethal ammonia exposures (Snyder-Conn et al. 2000). Sucker die-offs that occurred during late summer of 1995-1997 were usually associated with *F. columnare*. This ubiquitous pathogen appears to be only a problem when fish are stressed by poor water quality conditions and warm temperatures. Test fish were subjected to one of four sub-lethal ammonia concentrations at a pH of 9.5 for 30 days. After the 30 days, test fish were challenged with the bacterium for a 10-minute exposure. Few fish became infected with the bacterium. Results of this study may suggest that in nature, columnaris infection is of low virulence, and that infection is not dependent on ammonia concentration. However, it is possible that parasites and/or other water quality factors predispose the suckers to skin and gill damage, facilitating the columnaris infection typical in UKL suckers.

As part of the above experiment, histological specimens of kidney, gill, liver, pancreatic tissue, and intestinal tract from 4 ammonia exposure treatment groups of juvenile Lost River suckers were evaluated by light microscopy for abnormalities (Foott 2000). Differential leukocyte counts were performed on blood smears from the same groups. The proximate convoluted tubules in the kidneys of fish exposed at the medium (0.217 mg/l) and highest (0.440 mg/l) ammonia levels contained varying amounts of hyaline droplets. The severity of hydropic degeneration was correlated with ammonia concentration. Epithelial separation (edema) of the secondary gill lamellae was quite prevalent in the control ammonia group (0.006 mg/l NH_3-N) but not higher ammonia treatments. Both lesions were considered to be reversible and would not seriously affect the general health of the fish. No statistically significant trend in the lymphocyte:granulocyte ratio was detected among the blood smears of the treatment groups.

4.4.1.14 Sucker Condition (Health)

Larval and juvenile shortnose and Lost River suckers from Upper Klamath Lake were examined to determine anomaly rates for fins, eyes, spinal column, vertebrae, and osteocranium, and their possible associations with water quality and pesticides (Plunkett and Snyder-Conn 2000). Approximately 1,400 fish collected in 1993 were ranked on the severity of anomalies. One or more anomalies were observed in about 16% of shortnose suckers and 8% Lost River suckers. Anomaly rates exceeding 1%, greater than rates expected from high water quality systems, were observed for abnormalities of the spine, opercles, and pectoral and pelvic fins in shortnose suckers and abnormalities of opercles and vertebrae in Lost River suckers. Shortnose suckers exhibited higher rates than Lost River suckers for almost all anomalies. There were substantially more anomalies found in larvae and small juveniles than in larger juveniles. The anomalies described likely impair swimming, and could adversely affect feeding rates or avoidance of predators and adverse water quality conditions. Based on the high anomaly rates observed in this study, it is possible that age 0 suckers in Upper Klamath Lake are more vulnerable to mortality.

Numerous causes of high deformity rates in fishes have been identified, including genetics, pollutants, water quality, nutritional deficiencies, infectious agents, and physical and electrical shocks. Although no known studies have addressed natural anomaly rates in larval and juvenile fish, the anomaly rates in Upper Klamath Lake suckers are much higher than expected for high quality water systems. Although vertebral and opercular anomalies could be genetic in origin, based on their highest occurrences in small suckers, other types of anomalies do not fit the genetic hypothesis. Poor water quality and/or contaminants are also likely to contribute to the frequent high proportions of abnormal suckers in Upper Klamath Lake.

Adult shortnose and Lost River suckers from Upper Klamath Lake exhibited a wide range of physical afflictions that included eroded, deformed and missing fins; lordosis (forward curvature of the spine); pugheads; multiple types of water mold infections; redding of the fins and body caused by hemorrhage; cloudiness of the skin caused by decreased mucous production; pigmentation loss; parasitic infections of the body and gills; lamprey wounds; ulcers; cysts; gas emboli in the eyes; exophthalmos (protruding eyes); and cataracts (BRD 1997). The frequency of many afflictions was significantly greater in 1997 and 1998 than 1995 and 1996. Of the adult suckers captured from the Williamson River in April and May, 65-92% of the fish had some type of affliction in 1997-1998, whereas only 19-21% had afflictions in 1996.

The occurrence of the parasite, *Lernaea sp*., was 39% for shortnose suckers and 26% for Lost River suckers in 1999, down from 84% and 56%, respectively in 1997. Lamprey wounds were found in 17% of shortnose suckers and 30% of Lost River suckers in 1999, up from 16% and 19%, respectively in 1997. Various eye afflictions, fin damages, and other deformities were recorded for fish as well, but occurred in only a small percentage of fish captured.

4.4.1.15 Sucker Die-offs

Three large sucker die-offs were documented in 1995, 1996, and 1997. In 1995, the die-off occurred during September and October with 378 Lost River suckers and 124 shortnose suckers collected. A detailed discussion of the 1995 die-off was provided in Reclamation (1996a).

During July 1996, dead suckers began appearing in Upper Klamath Lake, presumably because of stressful conditions associated with poor water quality (high temperatures, high ammonia, low dissolved oxygen) and a bacterial disease outbreak. Between August 8 and October 3 - 6,049 dead suckers were collected (BRD 1996). The numbers peaked in Pelican Bay and Odessa Creek, the most frequently monitored areas, the weeks of August 26 and September 2. Lake-wide, the greatest numbers of suckers were collected the week of September 2. The weekly number of Lost River and shortnose suckers captured was quite similar between the two species.

Initial collections occurred from August 8 to August 20 in the clear water areas of Pelican Bay, and Odessa Creek. By August 23, it was apparent that the fish kill was becoming more widespread throughout the lake. Lake-wide surveys were attempted on August 26 and August 29; however, the quantity of dead suckers encountered precluded complete coverage of the lake on both occasions. Subsequent collections were made at various areas in the lake and along the shoreline. Fish kill monitoring in the clear water areas of Pelican Bay and nearby creeks (Harriman, Odessa, Short) was more rigorous and systematic than for the rest of the lake. These areas were thoroughly collected at two to four day intervals throughout the fish kill. Most fish were dip-netted off the bottom, with some found floating or along the shoreline. In other areas of the lake, fish were found floating and along the shoreline.

It was apparent that during the fish kill, many suckers moved to the clear water areas seeking better water quality. Suckers are rarely observed in these areas except possibly during the spawning season. Sick and dying fish have been documented in these areas from previous fish kill events (1971, 1986, 1995) (Buettner and Scoppettone 1990, Reclamation 1996a). Suckers collected from the clear water areas were generally larger specimens (BRD 1996, Perkins et al. 2000b). Samples collected from other areas around the lake included a wider range of sizes. Dead suckers and chubs were also collected in the C-Canal drop area during August and September (Gutermuth et al. 1997). About two-thirds were juveniles less than 300 mm FL and one-third adults. It appears that most of the smaller fish died in the canal rather than in the lake. Hundreds of adult suckers were collected in front of a log boom at the entrance to the A-Canal. Few small suckers were collected from the log boom.

It is difficult to assess the spatial distribution of the fish kill in 1996. Suckers were found dead throughout Upper Klamath Lake excluding Agency Lake. Highest densities of fish were also collected along the south shoreline (BRD 1996). The fish found in this area appeared more highly decomposed than those from other areas of the lake. We suspect that most of these fish died in the northern areas of the lake and were carried by wind-induced currents to the south end of the lake. Higher numbers of suckers were also collected from the eastern shoreline. Prevailing winds during this period were from the northwest. Hundreds of dead suckers were seen floating on the surface and hidden in dense beds of submerged aquatic vegetation in Pelican Bay. Most of these suckers were not collected.

The approximately 6,000 suckers collected during the fish kill undoubtedly represent only a small fraction of the number that died. Due to the poor water clarity in most lake areas, only fish floating or littered along the shoreline could be collected. Most likely, large numbers of dead fish sank to the bottom like those observed in the clear water areas. It is suspected that many dead fish initially sank to the bottom and then floated up after a period of days after bacterial decomposition occurred and the body cavity filled with gases. Attempts were made to evaluate dead sucker floating/sinking mechanisms to determine if estimates could be made of the percentage of dead fish floating (David Perkins per. com.). Experiments were highly variable and inconclusive.

At the south end of the lake, most fish were collected while walking along the shoreline. In this effort, many fish were found hidden in bulrush stands and others were partially or completely buried in the ground at the water/shoreline interface. Collections along the shoreline in other areas of the lake were less thorough with only fish readily observed by boat being collected. Based on the observation of field biologists, it was speculated that the number of fish collected may have represented only 2.5 to 10% of the suckers that were floating, which does not include dead fish that sank to the bottom and were never observed (BRD 1996).

Fish less than 300 mm FL were conspicuously absent from the fish kill. Also, smaller fish were not obvious among the sick fish in the clear water areas. On one occasion, large numbers of small chubs were seen floating on the lake; however hundreds of birds had eaten all the fish by the next day. Large concentrations of fish-eating birds have been seen on many occasions during the late summer months feeding on small fish. Thus, the thousands of birds in the vicinity of Upper Klamath Lake during the fish die-off may have effectively consumed most small fish that died in the fish kill. Nevertheless, Oregon State University noted a substantial drop in age 0 sucker cast net catches in September and October that may suggest that these fish were affected by the die-off (Simon and Markle 1997).

The length frequency distribution of Lost River suckers captured in the 1996 fish kill was generally similar to distribution of fish captured in the 1996 spawning assessment from the Williamson River. Fish from 400 to 500 mm were the most numerous size range for both the fish kill and the spawning run. The length frequency distribution of shortnose suckers greater than 300 mm FL that were captured in the 1996 fish kill were shifted about 30 mm larger than the distribution of fish captured in the spawning assessments of the same year. In the spawning assessment, shortnose suckers ranging from 320 to 400 mm were the most common sizes, while in the fish kill most were 350 to 440 mm. The difference in length distribution appears to be related to a non-random sample of the population for either the spawning group or the fish kill. When die-off frequencies are plotted for fish collected at springs (and freshwater inflow areas) and lake locations, it is apparent that the springs fish were larger (Perkins et al. 2000b). Several potential hypotheses to explain this are discussed in BRD (1996).

It appears that a bacterial disease (columnaris, *Flavobacterium columnare*) was the main infectious disease involved in the sucker die-offs but there may be other factors along with water temperatures that were predisposing the fish to infection (Holt 1996, Foott 1996). In 1996, pathological examinations were conducted on 26 sick and dying suckers at the Oregon Department of Fish and Wildlife Pathology Lab at Oregon State University. Columnaris bacteria were isolated from 24 of 26 specimens. Columnaris gill lesions were found in 78% of the Lost River suckers (9 total) and 77% of the shortnose suckers (17 total). No viruses were detected from these fish. Fungi were found in 58% and APS bacteria in 80% of the fish. Up to 23 leeches were attached in the mouth cavity producing ulcers and hemorrhaging. Few anchor worms were attached to the base of the fins. Internally, the fish appeared normal except for presence of white trematode cysts on the heart.

Histological examination of 12 moribund and 3 normal suckers were conducted by the US Fish and Wildlife Service Fish Health Center, Anderson, California (Foott 1996). Lesions characteristic of bacterial infections were seen in 14 of 15 fish. All of the fish showed kidney abnormalities. Specifically, degeneration of a specific region of the renal tubule was observed. The degenerated tissue observed in the kidney is indicative of toxic tubular necrosis that can be caused by heavy metals, pesticides and other poisons (Foott 1996). Also, this type of pathology has been observed in fish held in low and moderate concentrations of un-ionized ammonia for long periods of time. Such conditions occurred during fish kill years in Upper Klamath Lake.

It has been empirically shown that the fish kills were linked to a combination of meteorological and biological conditions (Perkins et al. 2000b). Specifically, warm weather and relatively calm conditions during July and August led to warm water temperatures, stratification of the water column and increased biological activity. Increased biological activity likely increased respiration and higher sediment oxygen demand. Blue-green algae populations that bloomed in June were generally declining. Fish were exposed to stressful levels of low dissolved oxygen that led to disease outbreaks and mortality.

In reviewing the Klamath Falls meteorological data records, we observed that weather conditions before and during the 1996 die-off were fairly severe. For example, the mean monthly July temperature was 73.5 F making it the second warmest in 69 years of record at the Klamath Falls airport. The August mean monthly temperature, 70 F, was ranked 11th. Warm weather was also associated with previous fish die-offs in 1995, 1986, and 1971.

Water temperature has been shown to be closely associated to air temperatures in Upper Klamath Lake (Wood et al. 1996). Because Upper Klamath Lake is so shallow and generally well mixed, water temperatures quickly respond to changes in air temperature. Lag time between changes in air temperature and water temperature appear to be only a few days during the summer.

Klamath Falls wind data indicate that July 1996 was ranked 4th out of the last 27 years for lowest mean monthly wind speed (3.2 mph). August was also a relatively calm month with an average monthly wind speed of 3.0 mph (5th out of 27 years). Wind records from the Klamath Falls airport generally indicate that winds are mostly light during the summer. However, on a daily basis winds frequently pick up during a portion of the day, typically during the afternoon and early evening hours.

A comparison of a wind speed index (maximum 4-hour running mean of each day) among years shows that the adult fish kill years of 1995-1997 were significantly less windy than other prior non fish kill years during the critical months of July and August (Klamath Tribes, unpublished data). This wind speed index is more likely to represent lake mixing conditions than would daily or monthly means due to higher mid to late afternoon winds commonly occurring on Upper Klamath Lake during summer months. These events are not as easily observed in the data when daily or monthly means are calculated, which tend to include long periods of zero wind occurring during nighttime hours.

Further analysis shows a clear relationship between this wind speed index and both water column stability and ammonia levels during July-August in Upper Klamath Lake (Klamath Tribes unpublished data). In summary, (1) water column stability is negatively related to lower off-bottom DO, (2) wind is negatively related to water column stability, and (3) wind is negatively related to ammonia (a positive relationship exists between water column stability and ammonia as well; Perkins et al. 2000b).

Cloud cover was also examined as it related to fish die-offs. In 1996, July and August were ranked 7th and 8th respectively as the sunniest months from the last 27 years. Sunny days can also be generally correlated to warm air temperatures during the summer. Sunny days generally dominate during summer months in all years.

Extensive water quality monitoring was conducted on UKL during 1996 that was used to evaluate lake conditions during the die-off. Beginning about mid-July and extending through August, blue-green algae populations were generally in a state of decline with a large biomass of dead and dieing algae. Associated with the algae decline were low dissolved oxygen concentrations. With calm conditions, stratification was common and near bottom DO was frequently below 5 mg/l (Perkins et al. 2000b).

From June through August ammonia levels and more importantly un-ionized ammonia levels were generally higher than any of the previous five years sampled. Mean lake-wide mean concentrations were 70-95 ug/l (Perkins et al. 2000b). High levels (200-400 ug/l) were observed at the northern sites in July (Mid North, Shoalwater Bay and Eagle Ridge). Although these concentrations were well below acute lethal levels for suckers, they may have contributed to stressful conditions leading up to the sucker die-off.

Another major fish die-off occurred in late summer 1997. The first signs of an impending fish kill were seen in mid July, when BRD noted a substantial increase in trammel net mortalities. Also, during the week of August 4, Cell Tech's fyke net collection of suckers exiting the lake via the Link River Dam increased sharply from tens of suckers in previous weeks to over 400 suckers. This exodus peaked the week of August 11 with over 1000 fish (Gutermuth et al. 1998b). During the week of August 11 chubs and suckers were first found dead throughout Upper Klamath Lake. Suckers were also observed congregating and dying at freshwater inflow areas (Pelican Bay, Williamson River, Odessa Creek). Dying suckers were observed to have numerous external parasites primarily anchor worms and to be lethargic in nature.

Over 2,300 large juvenile and adult suckers were collected in 1997, including 1,251 shortnose suckers and 885 Lost River suckers. The largest numbers of fish were collected from Pelican Bay (BRD, unpublished data). Substantial numbers were also gathered from the lower Williamson River, Ball Point and the mouth of Shoalwater Bay in the northern portion of the lake. Dead suckers were collected from July 23 to September 22 with a peak in late August. Adult blue chubs and tui chubs were the most frequently encountered fish littered along the shoreline of Upper Klamath Lake and lower Williamson River accounting for approximately 64% and 27% of the dead fish respectively. Rainbow trout, sculpins, and yellow perch were also collected. Approximately 90 trout were collected from the Pelican Bay/Harriman Creek area and lower Williamson River.

Dead and dying fish were provided to the Oregon Department of Fish and Wildlife Fish Pathology Lab and the U.S. Fish and Wildlife Service Fish Health Center for examination (Foott 1997, Holt 1997). Columnaris was recovered from 80% of the fish submitted and copepod (anchor worms) infestation was observed on 73% of the fish. No viruses were isolated. Foott (1997) noted a high prevalence of kidney abnormalities and systematic bacterial infections.

In addition to the large fish die-offs in 1995-1997, small, localized fish die-offs have been observed annually on Upper Klamath Lake since 1992 when extensive research and monitoring activities began. It is suspected that die-offs were also relatively common before 1992 but went unnoticed or unrecorded. Most recent die-off events have been small in size, localized, short-lived, and affecting mostly chubs and possibly small suckers.

Perkins et al. (2000b) analyzed the 1995-1997 fish die-off and associated water quality data. Major conclusions from the report included:

- During the summer months fish were exposed to stressful levels of pH, ammonia, and DO.
- At the time of the kills pH and un-ionized ammonia were generally not at stressful levels.
- In contrast, low dissolved oxygen (hypoxia) was associated with each of the kills.
- This consistent association, along with the bias toward larger fish in the die-offs, strongly suggests that hypoxia triggered the fish kills.
- Exposure to pH and ammonia stress likely increased the susceptibility of the fish to hypoxia.
- Stressors such as low DO, high pH, and ammonia also increase the probability of disease.
- The magnitude of the stressors may explain differences in fish kill composition. For example, in 1997, ammonia and hypoxia were worse than other years, and the fish kill was correspondingly worse.
- Sharp declines in algal abundance coincided with each of the fish kills and were the likely cause for the

hypoxia conditions that triggered the kills. In fact, evidence of the strong influence of algal bloom dynamics on DO concentration is shown by the significant positive relationship between net change in algal biomass and minimum DO during July-August.

- It appears that extended periods of water column stability, followed by a mixed water column at the time of algal collapse contributed to the kills. Low off-bottom DO and high water column ammonia characterized the period of water column stability preceding the kills, and a significant positive relationship existed between water column stability and surface-bottom dissolved oxygen difference during July-August.
- Water column stability leads to anoxic bottom waters and the accumulation of ammonia.
- A mixed water column during bloom declines extends hypoxic conditions throughout the water column, reducing avoidance ability.
- Poor water quality effectively reduces the amount of usable habitat.
- The effects of poor water quality on sucker populations in UKL were substantial; between 1995-1998 the abundance of spawners decreased 95% for Lost River suckers and 84% for shortnose suckers.
- Poor water quality may occur without a large adult fish kill simply because of low adult abundance.
- The life history strategy of these suckers is characterized by strong year classes that occur periodically; and as a result, these fish rely on low adult mortality and longevity to persist through periods of poor recruitment.
- The occurrence of three consecutive major fish kills raised the concern that the long-term viability of the populations may be jeopardized.
- These fish kills are symptoms of an ecosystem that has been disrupted for decades, and restoration of better water quality through the control of algal biomass is critical for the conservation of these endangered suckers.

Levels of dissolved oxygen, pH, and un-ionized ammonia achieved in UKL frequently exceed both chronically stressful and acutely lethal levels for the endangered suckers. During 1995-1997, years of major adult sucker die-offs, kills were both preceded by and initiated during a period of high pH, high un-ionized ammonia, and low off-bottom dissolved oxygen. This was followed by a period of low dissolved oxygen that extended throughout the water column for several days to weeks, coinciding with massive mortality of adult suckers. It is clear that photosynthetically elevated pH, low dissolved oxygen, and high un-ionized ammonia are key components of water quality profoundly affecting fish growth and survival in Upper Klamath Lake. Even during time periods when fish may not be exposed to lethal levels of these parameters, they can be nearly continuously exposed to levels that induce chronic stress. Subsequent immune system suppression then increases the risk of infection from diseases and pathogens such as Columnaris that has been involved in fish kills in Upper Klamath Lake.

Statistical modeling of water quality dynamics shows that a large magnitude and high rate of algal decline resulted in low dissolved oxygen during the late summer period when fish kills typically occur. This relationship demonstrates the critical link between algal biomass and dissolved oxygen during critical fish kill periods. Further modeling shows that high water column stability enhances low off-bottom dissolved oxygen and high un-ionized ammonia concentration. A more stable water column decreases atmospheric re-aeration, allowing both low off-bottom dissolved oxygen and high ammonia conditions to worsen. Water column stability is primarily controlled by wind, and it was significantly less windy in years with fish kills than in other years. Moreover, high ammonia levels, such as those occurring in the fish kill years, were significantly associated with low wind conditions. Thus, high algal biomass produces poor water quality conditions in Upper Klamath Lake, which interacts with climatic conditions to influence the severity of poor water quality and lethal conditions for endangered suckers.

Lake elevations during major Upper Klamath Lake fish die-offs (1971, 1986, 1995, 1996, 1997) were higher than average two years (1971, 1986) about average in 1995 and 1997 and slightly below average in 1996. In 1971, the lake elevation at the end of July corresponding to the peak die-off was 4142.7 compared to the mean elevation of 4141.26 for July. In 1986, the die-off began in late July at an elevation of 4141.5 approximately 0.25 feet above the mean July 30 elevation. During the peak about August 15, lake elevation was about 4141.0. In 1995, the die-off extended from early September to mid-October with a peak about September 23. Lake elevations during September started at 4140.7 (September 1) 0.4 feet above the average and ended the month about 0.2 feet less than the average (4139.7). Lake elevations during the 1996 die-off were approximately 0.5 feet less than the average end of August elevation and 0.6-0.8 feet less than average end of September elevations. In 1997, the end of August elevation was 4140.4 - 0.3 feet higher than the average. No obvious correlation exists between lake elevation and fish die-off events. Interestingly, no major adult sucker die-offs were noted during years with extremely low lake levels (1992, 1994). Discerning relationships between lake level and fish die-offs requires integration of climatic factors and algal bloom dynamics. Climatic conditions interact with lake level and bloom dynamics in a way that strongly influences how bad water quality conditions get. In addition, poor water quality may occur without a large adult fish kill simply because of low abundance of adult fish.

It should be pointed out that, despite having higher July-August wind speeds than the adult fish kill years of 1995-1997, the low lake level years of 1992 and 1994 still had some of the lowest minimum DO values (Perkins et al. 2000b). Major fish kills may have been barely avoided in these years, largely due to the fortuitous climatic conditions. Nevertheless, these were years of poor year-class formation.

Information from die-off events should be viewed with caution. It is unlikely that fish collected represent an unbiased sample of the Upper Klamath Lake population. This probable bias is related to different distribution of fish as well as differential mortality by species and life stage. For example, few trout have been encountered in past Upper Klamath Lake die-offs. There absence is probably related to their summer distribution in the tributaries and freshwater inflow areas around Upper Klamath Lake where water quality is good. In the 1986 sucker die-off, most suckers collected were large old Lost River suckers. However, two years after the die-off substantial numbers of younger Lost River suckers were documented in the spawning run that were not noted in 1986. In 1995, 378 Lost River and 124 shortnose suckers were collected in a die-off. This compares to 2,213 and 1,912 Lost River and shortnose suckers respectively in 1996. The ratio of Lost River to shortnose suckers was 3 to 1 in 1995 and 1.2 to 1 in 1996. This data suggests differential vulnerability to mortality each year. Also, the small number of suckers less than 300 mm FL may be related to differential mortality with larger fish affected more than small fish.

4.4.1.16 Sucker Genetics and Systematics

The Klamath River Basin is home to four species of suckers, the shortnose, Lost River, Klamath largescale, and Klamath smallscale. The taxonomic and reproductive status of these species has been unresolved by morphological and genetic studies to date (Miller and Smith 1981, Harris and Markle 1991). Additionally, these studies suggest that recent or historical introgressive hybridization has occurred among Klamath Basin suckers.

In 1997, Reclamation assembled several different laboratories using independent strategies to find genetic markers to resolve questions regarding reproductive isolation, classification, systematic relationships, and extent of hybridization among Klamath Basin suckers. Oregon State University has been studying sucker meristic and morphometric parameters and single copy nuclear DNA techniques. Arizona State University geneticists are using mitochondrial DNA sequence variation methods and University of California, Davis researchers have evaluated allozyme, amplified fragment length polymorphisms (AFLP) and nuclear microsatellite methods.

Wagman and Markle (2000a) examined 28 randomly chosen loci, sequenced 10,421base pairs, and found no fixed differences in four Klamath Basin sucker species. Some of the loci were much better markers for outgroup species, like the Klamath smallscale suckers from the Rogue River, than for the Klamath Basin suckers and suggested that the technique is useful. The authors concluded that based on their investigation that the Klamath Basin sucker species are similar genetically. Genetic similarity might be a result of hybridization and that hybridization could be a natural and necessary source of genetic variation.

Tranah and May (1999) screened 66 allozyme loci and determined that there was a lack of sufficiently diagnostic variation to continue to use this method. Use of AFLP techniques proved to be more diagnostic. A number of taxon specific markers were found for Lost River and smallscale suckers including several population specific markers. One marker specific to shortnose suckers was detected while no bands specific to largescale suckers were found. Interspecific comparisons demonstrated that shortnose and largescale suckers, although distinct, are genetically very similar. The close genetic relationship of these taxa suggests either recent introgressive hybridization or recent speciation between these groups. Lost River suckers from Clear Lake and Upper Klamath Lake are very similar and form a distinct group that is more closely related to the shortnose-largescale cluster than to the smallscale group. The Rogue River and Klamath populations of smallscale form the most distinct group.

Mitochondrial DNA studies produced similar preliminary results suggesting that all Klamath Basin suckers were similar genetically (Dowling 1999). He surmised that all species have been influenced by hybridization in the past, with recent isolation obtained by smallscale and Lost River suckers. Shortnose and largescale suckers were similar and gene exchange among these forms still occurs. Lost River suckers have retained substantial genetic variation.

Oregon State University and ASU combined merististic and morphometric and mitochondrial DNA analyses of Klamath Basin suckers (Markle et al. 2000b). Based on these efforts, four species can be recognized, each with two or more recognizable geographic forms. Rogue and Klamath basin smallscale suckers differ in morphological characters associated with dorsal fin placement and in mtDNA. Lost River and shortnose suckers from Lost River and Upper Klamath subbasins differed in meristic features with higher value in the Lost River subbasin. Klamath largescale suckers had morphological and meristic differences between the Upper Williamson, Sprague and Lost River subbasins and some individuals from the Upper Williamson had a unique mtDNA haplotype. Hybridization rates may approach 10% for some populations.

Markle et al. (2000b) state that all of the evidence supports the idea that Klamath Basin suckers are part of a species complex or syngameon. Syngameons are groups of interbreeding species that maintain their ecological, morphological, genetic, and evolutionary integrity in spite of hybridization. Botanists have many examples of syngameons, which have been ecologically and evolutionary distinct for millions of years and hybridizing throughout (Templeton as cited by Markle et al. 2000b). The morphological and ecological differences between species must be maintained by selection.

4.4.1.17 Radio Telemetry Study

Reclamation conducted radio telemetry studies of adult shortnose and Lost River suckers on Upper Klamath and Agency Lakes and tributaries from 1993 to 1999 (Peck 2000). Results from 1993-1995 are presented in the 1996 biological assessment (Reclamation 1996a).

In 1996, 18 radio-tagged adult suckers were monitored in Upper Klamath and Agency Lakes. Eight shortnose suckers and one Lost River sucker were captured and tagged at the mouth of the Wood River. Three adult shortnose suckers were captured from Upper Klamath Lake and the rest were from previous years tagging. By December 1996, only 7 active tags remained in the lake. During the fish die-off, 3 of 10 remaining 1996 tagged fish perished.

Radio-tagged shortnose suckers captured in Agency Lake during March and early April first entered the Wood River on April 24. Of the 5 radio-tagged fish that migrated upstream most fish occupied the Wood River during May. Fish moved upstream as far as Fort Klamath (rkm 20). Shortnose suckers remained in the river an average of 17 days (range 7-36 days). All tagged suckers had migrated back to the lake by June 12. By June 20, 6 of 8 shortnose suckers and the Lost River sucker that were tagged in the Wood River or Agency Lake near the mouth of the Wood River had moved to Upper Klamath Lake. Two shortnose suckers resided in Agency Lake near the mouth throughout the summer. During mid-September these two fish moved down to the Henzel Park area in the south part of Agency Lake. Water quality conditions were good by then throughout the lake.

Summer distribution of radio-tagged suckers was similar to that observed in previous years (Reclamation 1996a). In general most fish were tracked in open water areas in the upper one-third of the lake. During the sucker die-off there was no well-defined congregation of suckers at Fish Banks as was observed in 1995.

In 1997, Reclamation attempted to capture and track suckers occupying the lower lake area during late winter and spring. Although substantial effort was made to capture adult suckers in the area below Howard Bay only about 20 fish were captured. Radio tags were implanted into two shortnose and three Lost River suckers (Peck 2000). We also tracked two shortnose suckers tagged at the mouth of the Wood River in 1996 and one Lost River tagged at Ball Point in June 1997. In June the fish tagged in the lower lake moved up the lake and occupied various lake areas including Eagle Ridge, Offshore Williamson River, Offshore Pelican Bay, Mid North, Mid Lake, and Ball Bay. The two Agency Lake shortnose suckers moved into Upper Klamath Lake. Mid North and Offshore Pelican Bay were the most frequency occupied areas in June-August for Lost River suckers and July for shortnose suckers. Five out of seven (4/5 Lost River, 1/2 shortnose suckers) radio tagged suckers died during August concurrent with a fish die-off in Upper Klamath Lake. Only two radio tagged fish remained after August.

In 1998, we tracked three Lost River suckers captured in June at Ball Point and one shortnose sucker tagged in 1997 at Government Hill. Ball Bay was a highly used area in May, June, and July by both Lost River and shortnose suckers. Lost River suckers also occupied Offshore Pelican Bay from June-September and Mid North and Offshore Williamson River in July-September. The shortnose sucker was located at the Offshore Williamson River area in August-October.

In 1999, four shortnose suckers were captured and radio tagged in Agency Lake near the mouth of the Wood River in May. These fish all remained in Agency Lake and concentrated near the mouth of the Wood River during the summer months.

A high percentage of radio-tagged suckers died during the summer months and die-off periods. In 1995, three of 14 radio-tagged adults (2/9 shortnose, 1/5 Lost River suckers) died during the fish die-off. In 1996, 3 of 10 died (1/4 Lost River, 2/6 shortnose suckers) and in 1997 5 of 6 died (4/5 Lost River, 1/1 shortnose suckers) during the die-off periods. The greater loss of tagged fish in 1997 was consistent with the greater severity of the kill (Perkins et al. 2000b). Further, in 1993, 1994, and 1998 when adult sucker die-offs were not observed 2/8, 3/9, and 2/4, respectively died during the summer several months after tagging. Other tagged fish died during the first two months after tagging. These fish were excluded because their mortality was assumed to be associated with handling and surgery activities.

4.4.1.18 Adult Sucker Habitat Availability

Adult sucker habitat availability at different lake levels was assessed using information from adult sucker radio telemetry studies in Upper Klamath Lake from 1993-1998 (Peck 2000). Ninety-five percent of the observations in spring and summer months were at depths from 3 feet to 15 feet. One percent of the observations were in water of 3 feet or shallower and only 3% of Lost River suckers and 4% of shortnose sucker observations were found in water depths greater than 15 feet. These two depth ranges are evidently avoided by these species.

The shallower depth range avoided by suckers would not likely afford large fish suitable cover and as well, the conditions associated with those depths would likely be more turbulent due to wind-driven wave action. Light penetration and turbulence may also affect the abundance of food organisms. Algal blooms near the surface can cause greater elevations of pH in surface waters that may stimulate adult sucker avoidance. The deeper waters of Upper Klamath Lake (>15 feet) may not be hospitable to suckers due to the more frequent occurrence of low dissolved oxygen concentrations in summer months. Neither algal oxygen production nor atmospheric reaeration can improve low DO in deep waters of the lake. Unless there is substantial vertical mixing, low DO in deeper waters may also affect food organism abundance. Water depth sensors built into 8 radio tags deployed in the study (5 Lost River suckers and 3 shortnose suckers) confirmed that adults of both species are bottom oriented. None of the 96 measured fish depths showed that the fish were more than 1 foot above the bottom depth where these fish were located when water quality profiles were recorded. The confirmed bottom orientation of the suckers underscores the importance of the low off-bottom DO conditions that are prevalent in the lake during much of the summer.

Adult sucker depth preference was assessed by looking at radio-tagged sucker locations in September and October 1994, when Upper Klamath Lake levels dropped below 4137 feet. This period of minimal lake elevations provides the best basis to estimate true sucker species depth preferences. This is so because water quality conditions improve in the fall, removing the confounding influence on fish distributions due to poor water quality avoidance. Also, the relative areas of deeper water are at a minimum relative to the more expansive areas of shallow waters, challenging adult suckers to find and remain in deeper waters if that is their preference.

The 90 observations made in two months were associated with near bottom pH ranging from 7.3-9.0, water temperatures of 9.1-20.8 C, and dissolved oxygen from 3.8-11.2 mg/l. Only 1.1% of the fish were found in water less than 3 feet deep, representing 42% of the bottom area available at a lake elevation of 4137 feet. More than 90% of the fish use occurs in 54% of the available bottom area in the 3-9 foot depth range.

Fish preference indices were computed by taking the ratio of fish use to available bottom area in each depth category, with a ratio of 1.0 indicating that fish neither prefer or avoid a particular depth range. Preference for a depth range is indicated by a value greater than 1.0 and avoidance of a depth range results in a ratio value less than 1.0. Adult suckers showed a strong preference for the 6-9 foot depth range as 4.4 times as many fish were observed in 7.7% of the lake area in this depth interval. In contrast, strong avoidance of water depths less than 3 feet is evident even though water quality has improved in shallower waters relative to the summer months. Reclamation also conducted an extensive trammel netting survey from September 20 to November 3, 1994 to assess adult sucker distribution. Fifty-five net sets were made throughout UKL at a wide range of depths. Nets (300 feet long and 6 feet deep) were set for periods of 1-3 hours. Suckers were captured at depths ranging from 3 to 12 feet. Sucker catch rates were highest in 4-5 feet (4.0 fish per net). High catches also occurred in nets set in 3-4 feet (1.9 fish/net), 5-6 feet (3.4 fish/net), and 6-7 feet (1.9 fish/net). No nets were set in areas with depths of 7-9 feet. Percent zero catches were highest at sites with depths of 2-3 feet (50%) and 3-4 feet (62.5%). Zero catches were only 23.5% and 0% for 4-5 feet and 5-6 feet respectively.

Reclamation believes that although the UKL radio telemetry data appears to show that adult suckers have a preference for depths greater than 6 feet, a relatively high percentage were found at depths of 3-6 feet. It appears that a key element in their depth distribution is water clarity. Adult suckers generally avoid shallow clear water areas like the shoreline springs and freshwater inflow areas but can be found using shallow water depths when water clarity is low. For example, adult suckers were captured in highly turbid shallow shoreline areas (2-3 feet deep) in Clear Lake (Reclamation 1994). Also, radio tagged suckers concentrated in areas 3-4 feet deep in an area of Tule Lake with more turbid conditions. It is likely that radio tagged suckers in shallow areas of UKL moved to deeper areas as the boat approached during tracking. Since water clarity is usually low throughout the summer due to high algae densities water clarity conditions would allow adult sucker use of shallow water (3 feet). In 1994 when lake levels were extremely low adult suckers occupied shallower depths with 55% of the locations in 3-5 feet of water.

Potential habitat for adult suckers (> 3 feet) gradually decreases as lake levels drop from full pool (4143.3) to elevation 4141 (Table 8). However, between 4141 and 4140 the area decreases more dramatically (10%) and between 4140 and 4139 the change is 17%. Looking at the region of Upper Klamath Lake where most suckers inhabit, the changes are similar from full pool down to elevation 4140. However, between 4140 and 4139 the acreage decreases 22%.

Table 8. Potential sucker habitat greater than 3 feet deep in Upper Klamath and Agency Lakes.

Elevation	UKL and Agency		Northern Portion of UKL*		
feet msl	acres	%	acres	%	% of UKL and Agency
4143.3	66,430	100	28,565	100	43.0
4142	65,722	97.4	28,473	99.7	42.9
4141	62,768	94.5	28,021	98.1	42.2
4140	56,029	84.3	25,610	89.7	38.6
4139	44,228	66.6	19,242	67.4	29.0
4138	32,907	49.5	15,158	53.1	22.8
4137	24,867	37.4	12,303	43.1	18.5

* Only the northern portion of Upper Klamath Lake to the halfway between Eagle Point and Squaw Point was included because this is the lake area where over 95% of the radio tagged fish observations occurred.

4.4.1.19 Larval and Age 0 Juvenile Sucker Marsh Rearing Habitat Availability

Habitat utilization studies on sucker larvae and age 0 juveniles (young-of-the-year) have indicated that high densities occur in the shallow littoral areas (Buettner and Scoppettone 1990; Klamath Tribes 1991, 1995; Markle and Simon 1993; Simon et al. 1995, 1996). Microhabitat studies by the Klamath Tribes and OSU determined that sucker larvae generally occurred at higher densities in and adjacent to emergent vegetation than areas devoid of vegetation (Klamath Tribes 1995, Cooperman and Markle 2000). The Tribes also visually observed substantial numbers of age 0 juveniles in emergent vegetation in the Goose Bay area. In 2000, BRD using trap nets generally captured an equal or greater number of age 0 suckers in Goose Bay emergent vegetation than adjacent unvegetated areas (Rip Shively, BRD, per. com.). Age 0 suckers are also present in substantial numbers in unvegetated shoreline areas and open water areas (Simon et al. 2000a). There is a general movement by age 0 suckers from shoreline areas to offshore areas in August and September (Simon et al. 1996).

Structural elements provided by emergent vegetation have been shown to decrease the efficiency of fish predators on larval suckers in laboratory experiments (Klamath Tribes 1995). Structural complexity offered by vegetated habitats likely results in other benefits to larval and to a lesser extent age 0 suckers, including protection from waves during storm events, and increased diversity of zooplankton and other invertebrate prey.

Buettner and Scoppettone (1990) found that about 85% of the larval suckers were found in water depths between 10 and 50 cm (0.33 and 1.64 feet). In laboratory experiments, fathead minnow predation was reduced in tanks with structure and water depths of 0.3 m (about 1 foot) deep compared to unvegetated tanks (Klamath Tribes 1995). A depth of 1 foot is the approximate mid-point of this depth range and represents a conservative estimate of marsh water depth needed by larval suckers.

Reclamation computed percent marsh edge and marsh interior inundated to a depth of 1 foot and greater for northern Upper Klamath Lake and Agency Lake marsh areas. Reclamation elevation data was used for several larger marsh areas around the northern side of Upper Klamath Lake including Upper Klamath Marsh between Pelican Bay and Agency Lake and the marsh area from Pelican Bay to Odessa Creek and Wood River marsh in Agency Lake (Reclamation, unpublished data). Cumulative distribution of the sample points versus lake elevation were determined and graphed. The percentage of edge sample points was considered a surrogate for the percentage of linear marsh-water interface inundated at a given elevation. At elevation 4141.0 feet approximately 50% of the interior marsh habitat and 65% of the marsh edge habitat is available to larval and juvenile suckers. Available marsh edge habitat drops to 37% and interior marsh habitat to 10% at elevation 4140.0 feet. At elevation 4139 about 5% of the marsh edge is inundated to a depth of at least one foot and essentially none of the marsh interior habitat is available. Thirty-eight percent of the marsh edge and 10% of the marsh interior is inundated with water depths less than one foot.

Shoreline emergent habitats along the lower Williamson River and Upper Klamath Lake shoreline of the Williamson River delta were quantified in 1998 to assess how changes in lake pool elevation and shoreline morphology influence distribution and availability of habitats provided by emergent vegetation (Dunsmoor et al. 2000). Four dominant shoreline emergent types differed in distribution and character. Hardstem bulrush occurred primarily along shorelines with west aspects in the Goose Bay area. Burreed dominated the Tulana and River portions of the delta, occurring along shorelines with southwest aspects in areas where islands or offshore stands of emergent vegetation appear to offer protection from wave energy. Smartweed (*Polygonum coccineum)* was absent from the River but relatively common in Goose Bay and Tulana. Mixed bulrush/burreed stands were interspersed throughout the delta. Shorelines lacking emergents were common in Goose Bay (52%) and the River (54%), but not in Tulana (17%). Shoreline slopes and lakebed elevations at the outermost edge of the emergent vegetation were generally highest in the River, and lowest on Tulana shorelines. Emergent zone widths and cross-sectional areas were generally greatest on Tulana shorelines and least in the River. Shoreline aspect seemed to be an important determinant of wetland plant distribution, likely a result of shoreline interactions with wave energy. Shorelines exposed to the greatest fetch were dominated by shorelines devoid of emergents, but in Goose Bay within two miles of the river mouth these shorelines were frequently occupied by smartweed. This two-mile stretch of shoreline is a potential target for lake management oriented towards provision of larval nursery and dispersal habitat May through mid-July, because this species may provide stepping stones of habitat to the more heavily vegetated eastern portion of Goose Bay.

Marsh edge elevation of smartweed averaged 4140.35+/-0.08 ft SD in a study at Goose Bay in 1995 (Klamath Tribes 1995) compared to an average of 4140.35+/-0.18 ft SD measured in this study, indicating that little change had occurred. Marsh edge for smartweed was approximately one foot lower in the Tulana area (4139.19+/-0.09 ft SD). Other emergent vegetation types also extended out into deeper water in Tulana. Bulrush, burreed, and mixed bulrush/burreed had mean outermost edge elevations of 4139.25+/-0.55, 4139.14+/-0.25, and 4139.34+/-0.46 respectively.

Emergent zone habitat availability (1.0 feet and greater) in the lower Williamson River ranges from 25-35% at 4143, 2-5% at 4142 and 0% at 4141. At Goose Bay, 35-55% of the emergent zone is inundated to one foot or greater at 4143 and 5-20% at elevation 4142 feet. Only about 5% of the bulrush habitat is available at elevation 4141 feet. In the Tulana area, 35-60% of the emergent zone is available at 4143, 15-30% at 4142, and 5-7% at 4141.

Total emergent vegetation availability (inundated with water of any depth) ranges from 82.2-85.6% at 4143, 26.3-

37.5% at 4142, and 0.8-6.3% at 4141 in the lower Williamson River (Dunsmoor et al. 2000). At Goose Bay, 83.9-89.6% of the emergent zone is inundated at 4143, 34.2-54.8% at 4142, and 3.8-21.2% at 4141. In the Tulana area, 83.3-90.7% of the emergent zone is inundated at 4143, 44.1-62.3% at 4142 and 19.3-33.3% at 4141.

The results of Dunsmoor et al.'s (2000) analysis of habitat availability suggest lower habitat availability with respect to lake level than do Reclamation's results for availability of interior marsh habitat. For example, there is a loss of half of the marsh habitat volume at an elevation of 4142.0 ft in Dunsmoor et al. (2000) versus a loss of half of the habitat availability at 4141.0 ft in Reclamation's analysis. But this difference is essentially due to the difference in width and elevation gradient between the northern marshes and the narrow, shoreline marshes discussed above.

Surveys of emergent vegetation habitats were conducted in the lower Williamson River as early as 1991. In that year, the outermost extent of emergent vegetation was 4141.10+/-0.09 feet SD (Klamath Tribes 1991). In 1995, surveys within 0.5 miles of the mouth resulted in elevations of 4139.68+/-0.08 feet SD (Klamath Tribes 1995). Matthews and Barnard (1996) collected measurements of the outermost extent of the emergent zone in the lower mile of the Williamson River, yielding a mean elevation of 4140.68+/-0.48 feet SD. These measurements compare quite well with the most recent surveys in 1998, which averaged 4140.43+/-0.37 feet SD across all emergent types (Dunsmoor et al. 2000). Lower elevations measured in 1995 may reflect the influence of low water in 1992 and 1994, which may have allowed expansion of the emergent zone.

4.4.1.20 Shoreline Sucker Spawning Habitat Availability

In UKL sucker spawning has been documented at Sucker, Ouxy, Silver Building, and Boulder Springs along the eastern shoreline (Perkins et al. 2000a, Shively et al. 2000a). Spawning has also been documented at one non-spring shoreline area (Cinder Flat; Perkins et al. 2000a). During the late 1980's gravel and cobble substrates were added to Sucker Springs to enhance spawning success. Most of the other springs have not had gravels added although substrates at all of the shoreline sites have been affected by construction and maintenance of the Southern Pacific railroad that parallels the eastern shoreline of UKL. All of the cinder gravel substrate at Cinder Flat originated from the railroad.

At Sucker Springs the lower extent of the spawning gravel bed occurs at approximately elevation 4138.5. At elevations 4140, 4141, 4141.5, 4142.0, and 4142.5 feet 33%, 53%, 63%, 77%, and 92% of the spawning substrate is inundated to a depth of at least 1.0 feet (approximate minimum preferred depth for sucker spawning).

In 1995, the Klamath Tribes conducted an intensive sucker spawning survey at Sucker Springs (Klamath Tribes, unpublished data). This survey documented sucker spawning in water depths of 0.6-3.8 feet. Spawning occurred primarily at two locations, an inshore shallow area near the major spring discharge and a deeper area starting about 30 feet out from the shoreline. In the inshore spawning area, the 50% cumulative frequency depth was 1.8 feet, with half the measurements in deeper water and half in shallower water. For the offshore spawning area, the 50% cumulative frequency was 2.9 feet. Over 90% of the sucker embryos were found at depths of 1.0-3.5 feet. Nighttime visual observations have been made at the springs on numerous occasions over the last decade using night vision equipment (M. Buettner, Reclamation, personal observation). Sucker spawning was noted in water depths of approximately 0.5 feet and greater. The Tribes data indicates that at Sucker Springs most fish spawned at depths greater than 1.0 feet and may prefer depths greater than 1.5 feet. A greater depth of water (higher elevation) may provide security for spawning fish, increase the size of spawning areas, the opportunity (both behavioral and quantity) for spawning and increase the likelihood of greater productivity for critical early life periods.

Bathymetric surveys were conducted at Silver Building Springs, Ouxy Springs, and Cinder Flats in 1999 (Reclamation, unpublished data). Based on these surveys, Cinder Flat, Silver Building Springs, and Ouxy Springs initially become available for spawning (1 foot deep and greater) at elevations of approximately 4138, 4139, and 4140.5 feet respectively. At elevation 4141.0 48%, 25%, and 73% of the potential available spawning habitat is available at Silver Building Spring, Ouxy Spring, and Cinder Flat respectively. Spawning habitat availability at 4142.0 includes 70%, 61%, and 87% at Silver Building Spring, Ouxy Spring, and Cinder Flat, respectively.

4.4.1.21 Freshwater Inflow Area Use

A summary of information related to sucker use of freshwater inflow areas in Upper Klamath Lake was presented in the biological assessment of PacifiCorp and The New Earth Company operations associated with the Klamath Project (Reclamation 1996a). New information after 1995 was generally consistent with previous observations. Radio-tagged suckers did not utilize freshwater inflow areas during the summer and fall months. However, one of the radio-tagged suckers, an adult shortnose sucker, moved into the Williamson River near the Modoc Point Road bridge on August 14, 1997. This corresponded to a period of poor water quality and occurred during a fish die-off event. The fish moved back to the lake in late August and survived until June 1998.

Two and four radio-tagged shortnose suckers remained in close proximity to the Wood River in Agency Lake throughout the summers of 1996 and 1999, respectively (Reclamation, unpublished data). During the 1996 and 1997 die-offs sick and dying adult suckers were observed in Pelican Bay, Odessa Creek, Williamson River, and Short Creek. In 1996, the Klamath Tribes tagged sick suckers in Odessa Creek in an attempt to determine if they would recover. Almost all tagged fish were found dead in Odessa Creek within a couple of days. This data suggests that suckers generally enter the freshwater areas only when they are extremely sick and these locations might be considered dying grounds.

Suckers may use at least the Williamson River/Sprague River as a refuge to poor water quality based on the one radio-tagged fish and observations in the 1960's when substantial numbers of suckers were seen in the Williamson and Sprague rivers during August (Golden 1969). There were no reported sucker die-offs associated with these observations.

Adult suckers frequently used lake areas that are influenced by freshwater inflows during the summer (Peck 2000, Reclamation 1996a). They were typically located within a couple miles of Pelican Bay and the Fish Banks area. Other fish were found near the mouth of Odessa Creek, Short Creek and Wood River. During 1994, many of the radio-tagged suckers concentrated near the entrance to Pelican Bay during July when water depths were 3-4 feet. In August and September when lake levels dropped below 4138 radio-tagged suckers moved further offshore even though water quality remained good. Water depths dropped below 3 feet that appears to be the minimum depth for adult suckers based on the radio telemetry data.

Although transition areas between freshwater inflows and UKL generally have better water quality than the lake, conditions can at times be harmful to fish. During the 1995 sucker die-off, the Klamath Tribes monitored several sites in the transition area at the entrance to Pelican Bay. During the day cool Pelican Bay water with good water quality and high dissolved oxygen concentrations formed a wedge near the bottom of the lake while the upper water column conditions were warmer and oxygen levels were lower. With overnight cooling stratification broke down and the entire water column mixed. Dissolved oxygen concentrations in the morning were low throughout the water column (2.8 - 4.0 mg/l; Klamath Tribes, unpublished data).

4.4.22 Population Status

Data on Upper Klamath Lake Lost River and shortnose sucker population trends are poorly quantified. The only population estimates prior to 1996 were obtained in 1984 and 1985 (Bienz and Ziller 1987). These estimates were specific for spawning adults in the Sprague and Williamson Rivers. A general assessment of historic population trends was based mostly on annual creel census data from 1969 to 1986 (Oregon Department of Fish and Wildlife, unpublished data) and anecdotal information (USFWS 1993).

Loss or reduction of several spawning stocks is probably the most compelling data indicative of declining populations. Historical spawning areas that no longer support runs include: Odessa Creek, Fourmile Creek, Harriman Springs, Barkley Springs, Crooked Creek, Fort Creek, and Sevenmile Creek. Oregon State University also identified several shoreline springs along the east side of Upper Klamath Lake that probably once supported spawning groups that apparently are not presently being used (OSU, unpublished data).

Spawning runs in the Sprague River above Sprague River Dam have been depressed for many years due in part to poorly designed and maintained passage facilities at the dam (Buettner and Scoppettone 1990). This long river reach likely supported large spawning runs. Additionally, the severely degraded river habitats and high abundance of exotic percids and centrarchids in the Sprague River above the dam also contributed to the low populations. In 1996, a small spawning run of shortnose suckers was documented in the Wood River (Reclamation, unpublished data). However, no Lost River suckers were sampled from the river.

In the 1980's, Lost River sucker spawning runs in the Williamson and Sprague Rivers were dominated by large presumably older fish (Buettner and Scoppettone 1990). Aging data collected from a lake die-off in 1986, indicated that most fish were 19-28 years old. Twenty-six year classes were documented with fish ranging from 8 to 43 years old. In 1988, 33 Lost River suckers were aged from spawning runs up the Sprague and Williamson rivers. These fish ranged from 9-30 years old with most 10 and 11 years.

Shortnose sucker spawning runs in the 1980's in the Williamson and Sprague Rivers were numerically small (Buettner and Scoppettone 1990). Length frequency and ageing data was not nearly as extensive as for Lost River suckers. Only 18 shortnose suckers were aged from 1986 to 1988. They ranged from 4 to 25 years and represented 12 year-classes.

The Klamath Tribes captured small numbers of suckers from the Sprague and Williamson Rivers from 1989 through 1996 for hatchery propagation and other research purposes. Size distribution of these captures was presented by BRD (1996). Although the sample sizes were small, Lost River sucker distributions were similar from 1989 to 1994 with mostly larger fish (500-750 mm FL). Size distribution of the 1995 and 1996 Lost River spawning runs in the Williamson and Sprague Rivers were shifted downward. Most fish were 400-500 mm FL compared to 550-700 mm FL previously.

Shortnose sucker size distributions from 1989 to 1994 were similar to those from the 1980's with most fish ranging from 375-500 mm FL (BRD 1996). Size distribution of the 1995 and 1996 shortnose sucker runs in the Sprague and Williamson Rivers were mostly 300-400 mm FL.

The shift in size distribution appeared to be related to recent recruitment to the adult population combined with a disappearance of older year classes. Age distribution information is based mostly on fish die-off events during 1995 (Reclamation 1996), 1996 (BRD 1996) and 1997 (BRD, unpublished data). Ninety-five percent of the suckers were age 7 years or younger with most age 4 (1991 year-class). Only 14 and 9 year-classes were documented for Lost River and shortnose suckers respectively.

Examination of about 860 suckers from the 1996 fish kill documented Lost River and shortnose suckers that were mostly 2-8 years old (BRD, unpublished data). Eighteen year-classes of Lost River suckers and 11 year-classes of shortnose suckers were identified. The most abundant year-class of both species was 1991; the 1988, 1989, 1990 and 1993 year classes were also fairly well represented. In 1997, older Lost River and shortnose suckers were present in higher numbers from the die-off with 28 and 20 year-classes represented respectively.

4.4.23 Upper Klamath Lake Water Quality

The hypereutrophic status and concomitant poor water quality of Upper Klamath Lake is well documented (USACE 1982; Kann and Smith 1993; Kann 1993a,b). Extensive blooms of the blue-green alga *Aphanizomenon flos-aquae* cause significant water quality deterioration due to photosynthetically elevated pH (Kann and Smith 1993) and to both supersaturated and low dissolved oxygen concentrations (Kann 1993a, 1993b). Both pH and dissolved oxygen achieve lethal levels in Upper Klamath Lake, and as such are important variables affecting survival and viability of native fishes in Upper Klamath Lake. Bioassays have shown that pH values >9.55 caused a loss of equilibrium in juvenile shortnose suckers (Falter and Cech 1991), and that values >10.3 proved lethal to larval and juvenile shortnose and Lost River suckers (Saiki et al. 1999). Bioassays also show that dissolved oxygen conditions <2.4 mg/l are lethal to larval and juvenile shortnose suckers. It is important to note that sub-lethal effects are likely to occur prior to reaching the lethal levels described above (Kann and Smith 1993). Meyer et al. (2000) documented structural changes in the gills of larvae exposed to unionized ammonia concentrations 3.5 times lower than the lowest concentration at which significant growth and mortality effects occurred. Swimming performance of larval Lost River suckers was reduced at pH of 10.0.

Volume and mean depth (elevation) have a direct effect on physical, chemical, and biological processes in lake systems. There is a direct reduction of habitat available for fishes as lake level is lowered, particularly the reduction in shoreline rearing habitat of larval and juvenile endangered sucker species (Dunsmoor et al. 2000, Klamath Tribes 1995). In addition, lowered lake elevation and volume can exacerbate various productivity related water quality problems.

The Klamath Tribes and Reclamation have been intensively monitoring limnological conditions in Upper Klamath Lake in recent years to document temporal and spatial variability in water quality, nutrients, and algal biomass. This work was also aimed at identification of major factors affecting algal bloom dynamics and associated water quality including lake level regulation. Several reports have been completed analyzing this information (Kann 1993a, 1993b; Kann and Smith 1993; Klamath Tribes 1995; Jassby and Goldman 1995; Wood et al. 1996; Kann and Smith 1999; Kann 1998). The following section attempts to summarize pertinent lake elevation regulation related information discussed in the references cited above.

The relationship of algal-induced water quality changes to fish growth and survival in hypereutrophic lakes and how that relationship is induced by lake elevation is important. High nutrient loading promotes correspondingly high production of algae, which, in turn, modifies physical and chemical water quality characteristics that can directly diminish the survival and production of fish populations. Lowered lake elevations often increase algal production and worsen water quality. The following chain of causal relationships and mechanisms, which is supported by the literature, is characteristic of most fresh water lake systems.

Nutrient Input →Algal Growth→Water Quality Changes→Fish Survival and Propagation

Under conditions of high nutrient input, algal production increases and algal biomass accumulates until some factor, either light or nutrients, limits further growth. As biomass increases, the available soluble forms of nitrogen (N) and phosphorus (P) decrease, because the nutrients are progressively accumulated in the biomass, and are therefore unavailable for further biomass increase. The nutrient in shortest supply, relative to growth requirements, is the limiting nutrient at that time.

In the process of rapid growth, algal biomass can reach "bloom" proportions, which can vary in magnitude depending on the availability of growth-promoting conditions and losses. If the bloom is large enough, and mixing/reaeration are minimal, pH will increase because the rate of CO_2 fixation through photosynthesis exceeds the rate of input from the atmosphere, shifting the equilibrium between free CO_2 and carbonate ions in the water. Acutely toxic levels of pH are common during afternoons in hypereutrophic lakes and can produce high un-ionized ammonia and P internal loading. During the same bloom conditions, particularly when coupled with high rates of nighttime respiration, DO can drop to levels that restrict growth of or are even lethal to fish. Such pH and DO events usually occur in mid- to late-summer in shallow hypereutrophic water bodies like Upper Klamath Lake.

In addition, when high levels of algal biomass die off, the microbial degradation of the algae and oxygen demand by sediment can further deplete DO and produce increased concentrations of ammonia, adversely affecting fish (Barica 1974). The extent of DO depletion and pH and ammonia increase by these processes can be accentuated by low lake volume and shallow depth, i.e. the potential for stress-inducing water quality is always present in proportion to algal production, lake volume, lake depth, and lake volume relative to sediment area. These processes are also affected by wind mixing.

4.4.1.24 Phosphorus

Phosphorus is of particular concern in Upper Klamath Lake due to its role in determining algal productivity and biomass, which in turn influences water quality conditions affecting fishes (eg. high pH and severe diel swings in dissolved oxygen). Parameters that determine phosphorus concentration in the lake include: inflow phosphorus, internally regenerated phosphorus from sediments, inflow water volume, and lake volume. Nutrient loading studies show that the largest flux of phosphorus to Upper Klamath Lake during the summer months comes from internal sources (Kann and Walker 1999). One important mechanism for release of phosphorus in shallow productive lakes is photosynthetically elevated pH (Welch 1992; Sondergaard 1988; Jacoby et al. 1982). Elevated pH can increase phosphorus flux to the water column by solublizing iron-bound phosphorus in both bottom and re-suspended sediments as high pH causes increased competition between hydroxyl ions and phosphate ions decreasing the sorption of phosphate on iron. Evidence for this exists in Upper Klamath Lake where it was shown that the phosphorus associated with hydrated iron oxides in the sediment was the principal source of P to the overlying water, and that iron-phosphorus fractions decreased from May to June and July (Wildung et al. 1977). A similar mechanism occurs with phosphorus adsorbed by aluminum (Jassby and Goldman 1995). In addition, the probability of achieving increased internal loading rates increases with pH, and it appears that about 9.3 is the pH level at which the probability of internal loading sharply increases (Kann 1998). Empirical evidence from Upper Klamath Lake along with supportive evidence from other lakes indicates that as the bloom progresses and elevated pH increases the flux of phosphorus to the water column, increased water column phosphorus concentration further elevates algal biomass and pH, setting up a positive feedback loop (Kann 1998).

Low lake volume can further accelerate this feedback mechanism through two mechanisms. First, the lower water volume does not dilute the phosphorus influx to the extent a higher volume would, which is especially significant when internal loading is high. Secondly, as water depth decreases, resuspension of bottom sediments by wind action occurs more frequently and the quantity of sediments resuspended also tends to be greater. Such resuspension events are significant because while high pH solubilizes phosphorus and makes it available for algal growth, wind resuspension increases sediment contact with the water column which optimizes the freeing of iron-bond phosphorus (Sondergaard 1988). As such, higher lake volume would be expected to decrease the phosphorus available for algal growth by dilution and decreased frequency and magnitude of resuspension. In fact, when algal biomass is high (chlorophyll a > 100 ug/l) Upper Klamath Lake data show that as lake elevation declines, higher lake-wide mean phosphorus concentration (June-August) is achieved (Kann 1995). In other words at a high algal biomass threshold when pH is likely to be elevated, low lake volume appears to exert a positive influence on phosphorus concentration. In addition a significant relationship exists between algal biomass and lake volume in June when pH >9.3.

A low lake level could enhance internal loading by increasing the bottom shear stress generated by a wind of a given magnitude. Theoretical estimates using Upper Klamath Lake bathymetry indicated that the bottom shear stress created by a 10 mph wind at lake elevations as low as 4137 could be very effective at resuspending sediment (Laenen and LeTourneau 1996). The same analysis indicated that the areally weighted bottom shear stress of 4140 elevation would be about one-half that at 4137, but could still be at a value that could effectively resuspend sediment. Subsequent analysis during this study indicated that bottom shear stress decreases rapidly for lake elevations above 4140. The dilutional effect of lake level on internal loading is a known physical principle.

Wood et al. (1996) stated that a critical set of circumstances is required to initiate internal loading of phosphorus; lake level is only one of those circumstances, and its relative importance is unknown. The authors concluded that the phosphorus dataset analyzed in this study was not sufficient to quantify the contributions of wind magnitude, fetch, high pH, and lake level (four of the most easily identified relevant variables) to the internal loading of phosphorus. However, the pH/internal loading relationship has been quantified by Kann (1998).

Rather than combining the seasonal (June-August) total phosphorus data set for each year as the Klamath Tribes had done, USGS analyzed the data on a month by month basis. They also plotted the data set over the growing season by station. Phosphorus concentration was, at times, highly variable around the lake. They determined that there was an apparent relation between total phosphorus concentration and lake level during June. Further, total phosphorus concentration in June was correlated with chlorophyll-a concentration in June, suggesting that the strength of the first bloom is influenced by phosphorus concentration. External loading from spring runoff could be an important factor in determining the phosphorus concentration in the lake at that time. However, data clear show that internal loading is more important than external loading in June (Kann 1998, Kann and Walker 1999).

4.4.1.25 Chlorophyll-a and pH

Chlorophyll-a has been demonstrated to be a good predictor of pH in UKL, especially in June when algal biomass is increasing and cells are healthy (Kann and Smith 1999). The photosynthetic effect of large, active biomass levels of algae in a relatively soft-water lake like UKL, can drastically raise pH to levels detrimental to fish. Because the response of pH to the intensity of algal photosynthesis is rapid, the use of data from individual dates, as well as from monthly or seasonal means is valid. Kann and Smith (1999) developed two separate statistical models between chlorophyll-a and pH. The regression model developed between lake-wide mean values of chlorophyll-a and pH in UKL for the June-September period yielded an r2 value of 0.72. This value increased to 0.95 when the model was developed from UKL June chlorophyll-a and pH. The year with the highest June chlorophyll-a (1992) also had the highest June median pH (about 9.9) and the lowest lake level (Kann and Smith 1999).

Wood et al. (1996) concluded that there was no evidence for a relation between chlorophyll-a and lake level on the basis of seasonal distribution of data or a summary seasonal statistic. USGS updated data analyses from their earlier report (1990-1999). Inclusion of five more years of data did not demonstrate a discernable relation. However, other contributing factors must also be analyzed between lake level and algal biomass. June was an important month to examine chlorophyll-a and pH because the first algae bloom of the year usually started in late May, June, or early July. In June it was found that the concentration of chlorophyll-a and the frequency of very high pH values were lower at higher lake levels, and that the start of the first bloom was delayed at higher lake levels (Wood et al. 1996, USGS, unpublished data). Because of the relation between pH and algal growth, the dependence of pH on lake level and degree-days parallels to some extent the dependence of chlorophyll-a on lake level and degree-days. An earlier bloom leads to an earlier rise in chlorophyll-a in June and consequently an earlier rise in pH.

4.4.1.26 Dissolved Oxygen

The potential for low dissolved oxygen concentration increases later in the growing season (July-September) when the algae blooms have crashed and considerable organic matter has accumulated in the sediments. During this same period increased water temperature increases water column depletion rates as decomposition and respiration take place at a faster rate, and oxygen concentration in the water column tends to be lower because solubility of oxygen decreases as water temperature increases. In addition, the ratio of lake volume to sediment surface area decreases as lake volume decreases (Kann 1995). In theory as this ratio decreases the depletion rate of dissolved oxygen in the water column increases because the lower water volume holds less oxygen relative to the biochemical oxygen demand (BOD) of the sediments. The inverse relationship between mean depth and the volume-based oxygen depletion rate has been demonstrated under ice in numerous lakes, and the greatest depletion rates occur in very eutrophic lakes (Mathias and Barica 1980). In shallow lakes like Upper Klamath Lake reaeration from the atmosphere can increase water column dissolved oxygen concentration. However, the depletion rate is further increased when metabolic demands (e.g. of bacterial decomposers and fish) are maximized by high water temperatures and increased resuspension of sediments occurs.

Considered together, these physical, chemical and biological processes may increase the probability that fish in Upper Klamath Lake will experience stress or death from inadequate dissolved oxygen concentration as lake levels decrease. Seasonal (June-August) mean dissolved oxygen plotted for both the water column mean and minima show a positive relationship with season median lake volume (Klamath Tribes 1995). Seasonal box plots also shows that the two years of lower elevation (1992 and 1994) have a greater frequency of minimum dissolved oxygen measurements falling within the lethal range (ca. 2.5 mg/l) in July and August.

The Klamath Tribes conducted additional analyses of UKL dissolved oxygen data from 1990-1995 grouping two-year pairs with similar July and August elevations (Klamath Tribes, unpublished data). Box plots showed that the water column mean dissolved oxygen and water column minima were lowest for the low lake grouping. This relation held under several combinations of stations in Upper Klamath and Agency lakes. Jassby and Goldman (1995) conducted a similar analysis of the DO data, grouping 1992 and 1994 as low lake elevation years and 1990, 1991, and 1993 as high elevation years for July-September. They observed a consistent difference between low elevation and high elevation years at all stations, with a tendency for minimum DO to be lower in low-elevation years. For each station, both the median and the lowest value were smaller during low elevation years. The Klamath Tribes also determined that the percentage of water column minima less than 5 mg/l (July-August) was highest for the low lake years. When all 9 sites were considered, 35% of the July-August water column minimum were less than 5 mg/l compared to 26% for the middle group and 20% for the high group.

USGS (Wood et al. 1996) analyzed the 1990-1994 UKL oxygen data and concluded that the data are not sufficient to distinguish the relative importance of the various processes and the possible artifacts of data collection that determined the measured concentration. Because similar lake levels resulted in quite different dissolved oxygen concentrations, however, it is most likely that temporal trends were determined primarily by seasonal factors, such as the algal growth cycle and water temperature control of saturation. Nonetheless, the extent to which oxygen demands that are enhanced by lower lake levels superimpose on other seasonal effects and influence the lower extremes of the distribution of dissolved oxygen concentration cannot be quantified with this dataset. Addition of five more years of data (1995-1999) to the analysis did not result in a discernable DO lake level relation (USGS, unpublished data).

It is important to note that the winter under-ice dissolved oxygen concentrations can be low given UKL high biomass production and large sediment oxygen demand. When there is sufficient light penetration for photosynthesis to occur, the production of oxygen can offset the depletion occurring from sediment demand and respiration. Snow depth is an important factor determining the DO depletion rate.

Upper Klamath Lake data during ice-cover conditions from 1988, 1989 and 1993 indicate there is almost always severe DO depletion at near bottom depths (Klamath Tribes unpublished data). This depletion will migrate up into the water column as the season progresses due to the prevention of air-water diffusion processes by ice-cover. The lower the light penetration the faster the depletion will occur. Dissolved oxygen concentrations from several dates and sites were highest at the surface and lowest at the deepest measured depth. DO values below 5 mg/l were commonly observed at depths greater than 2 feet and concentrations of less than 1 mg/l were documented at several sites during 1988, 1989, and 1993 (Klamath Tribes unpublished data).

Lake volume (elevation) under-ice conditions influences the rate of DO depletion. For example, a change in lake elevation from 4140 to 4137 results in a 40% reduction in mean water column depth. With a larger sediment to volume ratio at lower lake elevations, DO depletion will occur faster than at higher lake elevations. Therefore, theoretically there is a higher probability of low dissolved oxygen at lower elevations. Under-ice dissolved oxygen concentrations less than 5 mg/l were measured at elevations 4139.5 (1993), 4140.9 (1988), 4141.1 (1989) and 4141.7 (1988). Because low DO occurred at a wide range of elevations fish may be even more vulnerable to poor water quality during the winter when ice-cover conditions prevent air-water diffusion.

4.4.1.27 Water Temperature

Lake temperature is one example of an important physical parameter affected by volume and depth. For example, shallow lakes exhibit more rapid heating and cooling than adjacent deep lakes, and require less solar radiation in spring to raise the temperature of epilimnetic (surface) waters (Goldman and Horne 1983). Because *Aphanizomenon flos-aquae* bloom initiation is often linked to temperature increases in the spring when temperatures reach 15-17 C, lake volume has the potential to affect the timing of late-spring early-summer blooms. At low lake volume, warm late-spring and early-summer air temperatures can translate more directly to warmer water temperatures which in turn can cause early bloom development and faster algal growth rates. Because maximum UKL elevations also occur during cooler (and presumably wetter) late winter and spring conditions, it is not possible to determine statistically the relative effects of volume and degree-days.

Wood et al. (1996) suggested that the time from April 1 to the start of blooms in the spring was determined more by water temperature, specifically by degree-days since April 1, than by lake level. Nevertheless, the year with the earliest large bloom was 1992 (June), which was the year with the lowest spring-time lake level throughout the 1990-1999 monitoring program. The bloom also began early in 1994, but was slower to reach a lower maximum. The latest algae bloom of significant magnitude in Upper Klamath Lake occurred in September 1991, but chlorophyll-a still reached 280 ug/l.

Wood et al. (1996) showed that June chlorophyll-a in Upper Klamath Lake was directly related to degree-days after April 1, implying that a longer exposure to higher temperature would produce more biomass. Kann (1998) further investigated the hypothesis of temperature control of bloom timing with a longer data set (1990-1996) and found that the relationship between time when the blue-green algae reached a given biomass and degree-days since April 1 was relatively strong. The delayed bloom of 1991 coincided with the fewest degree-days during April 1-May 15 and the 1992 bloom experienced the most degree-days. Also, the Klamath Tribes (Klamath Tribes, unpublished data) showed a positive relationship between the time for a given biomass and the time when the first 7 consecutive day air temperatures reached 15 C.

USGS compared Klamath Falls air temperatures and UKL water temperatures from 1992-1994 (Wood et al. 1996). They observed that air temperature exerts a strong influence on lake temperature because daily to weekly fluctuations in the 1-m water temperature records parallel the air temperature, with a lag time of a few days. This does not mean that air temperature determines the absolute temperature in the lake; the absolute temperature is determined by the overall heat budget, of which air temperature is only one component. Because lake elevations during the late-spring/early-summer only vary about one foot between high and low elevation years, water elevation is not likely to be an important factor affecting water temperature at that time of year. However, during the late-summer when the lake elevation difference between a high and low elevation year can be 4-5 feet, lake elevation may be a significant factor affecting temperature with a lag time to equilibrium as much as 10 days. It has also been surmised that there may be a greater daily temperature fluctuation at a lower lake elevation (Jacob Kann, Aquatic Ecosystem Sciences, per. com.).

USGS investigated the dependence of water quality variables on air temperature and cloud cover (Wood et al. 1996). They concluded that year-to-year differences in the timing of the first bloom are related to year-to-year differences in the number of degree-days between April 1 and May 15, such that the bloom occurs earlier at a higher number of degree-days. The data also supported the hypothesis that year-to-year differences in June chlorophyll-a concentration are related to year-to-year differences in the number of degree-days between April 1 and May 15, such that concentrations are higher at a higher number of degree-days. The cloud cover index corresponds well with the number of degree-days, with a higher number of degree-days being associated with more sunshine and a higher index. Lake level and climate variables may act concurrently or in conjunction with each other to affect water quality, or one of them may be a real causal factor whereas the other is not. High spring lake levels were also related to later blooms (Kann 1998).

4.4.1.28 Algal Productivity and Depth

The Klamath Tribes measured light extinction on several occasions throughout the summer in 1994 and correlated it with Secchi disk depths (Kann 1998). They documented that little to no surface light remains below a depth of one meter. This pattern was very consistent for all sites and years during the June-September growing season using Secchi disc transparency. As a result, algal productivity generally becomes light limited below one meter such that all productivity is relegated to the top meter of the water column. Thus, in a mixed situation (which frequently occurs in UKL) algal cells spend a proportion of time at deeper depths where respiration exceeds photosynthesis, greatly retarding productivity. The deeper the water column the greater the proportion of time that algal cells will be light limited thereby reducing photosynthetically elevated pH (which can be toxic to fish), and affecting the timing and magnitude of blooms in a positive way with respect to fishes. In addition, any pH reduction theoretically can be expected to further reduce internal phosphorus loading. At any time during the growing season when light is limiting, the pH response to a given algal biomass will be incrementally less when depth increases. Because lake elevation reductions as little as three feet translate into about 40% reductions in mean depth, these are not small effects and can decrease the impact of poor water quality events when climatic variables are conducive for algal growth.

Probability models of photosynthetically elevated pH as a function of algal biomass (chlorophyll a) were developed for both Agency Lake and Upper Klamath Lake (Kann and Smith 1999). A linear relationship between chlorophyll-a and pH was demonstrated for both Agency and Upper Klamath Lake (June-September). However, for Agency Lake lower chlorophyll-a levels were associated with high pH than in Upper Klamath Lake. Probability plots for regression-based probability models of exceeding critical pH levels as a function of chlorophyll-a concentration were also illustrative of the relation. At a chlorophyll-a value of 100 ug/l there is an 18% probability of exceeding pH 9.5 for the Upper Klamath Lake-wide mean model, while for the Agency Lake model there is a 40% probability of exceeding pH 9.5 at this same chlorophyll level. Given that Agency Lake has a mean depth nearly 1 meter less (or 40% less water column) than Upper Klamath Lake, the light limitation mechanism can easily contribute to the greater than 2X difference in probability of exceeding pH 9.5 in Agency Lake (Kann and Smith 1999). In effect the deeper water column is diluting the high pH generated by the photosynthesizing algae since productivity is limited to the top 1 meter of the water column. These benefits are in addition to any dilution of internal loading that would occur with greater lake volume, and a reduction in pH induced internal loading.

Initiation of blue-green algae blooms has also been linked to inoculation of the water column by migrating cells from the sediment (Barbiero and Welch 1992). Migration of *Aphanizomenon* from the sediment contributed as much as eight percent of the observed water column increase in biomass of that species in Agency Lake in 1992 (Barbiero and Kann 1994). Although the trigger that causes migration is not well understood, these authors suggest that a threshold for light reaching the sediment may be more important than temperature. A deeper water column during the spring may delay the initiation of the first blue-green algae bloom.

4.4.1.29 Hanks Marsh Water Quality

An investigation of the physical, chemical and biological characteristics of Hanks Marsh was conducted by the National Biological Service from 1992 to 1994 (Forbes et al. 1996). This study provides the most detailed information of water quality in littoral wetlands in Upper Klamath Lake to date and allows for comparison with water quality conditions in pelagic areas.

Results of this study are for the most part consistent with what is known about physical and chemical conditions in littoral areas. Several parameters were distinctly different from open waters, forming a horizontal gradient as distance from the pelagic zone increased. These differences are related to the dominance by emergent vegetation and resulting sheltered conditions that lead to hydrologic isolation. Conductivity, dissolved solids, pH, phosphate, and nitrate ions, and total phosphorus formed a horizontal gradient of increasing concentrations.

Planktonic algae blooms that are so prevalent in open water areas were not observed in the marsh. Although the exact mechanisms are not well understood, the relationship between humate content and inhibition of many planktonic algae species has been established on both a local and national level (Phinney et al. 1959; Perdue et al. 1981; Wetzel 1993). Other contributing factors include light limitation and low pH.

Most parameters exhibited substantial seasonal variations. On a study-wide basis, however, phosphorus, inorganic nitrogen, and chlorophyll-a levels were more similar to lake water than to levels found in selected tributaries. The results of this study do not address the flux of material between the pelagic and littoral zones. Some of the data suggest, however, that pelagic conditions influence the outer areas of Hanks Marsh. Conversely, processes within the marsh may form water quality gradients that extend into the pelagic zone. Hazel (1969) documented a hydrogen ion gradient extending into the lake from Hanks Marsh.

The physical and chemical characteristics of large littoral marshes around Upper Klamath Lake may historically have played an important role in regulating the algal community and other characteristics of the system. Littoral wetlands have been drastically reduced in size due to agricultural reclamation. Since 1940, 23,000 acres have been diked and drained in Upper Klamath Lake (Carlson 1993) with total losses of about 50% lost since development began over 100 years ago. Approximately 15,000 of these acres are in the process of being restored to wetlands. However, they are not open to the lake.

4.4.1.30 Upper Klamath Lake Nutrient Loading

Despite high background P levels in Upper Klamath Basin tributaries and springs (Kann and Walker 1999, Rykbost 1999), data exists from several studies to indicate that P loading and concentrations are elevated substantially above these background levels (Miller and Tash 1967; USACE 1982; Reclamation 1993a; USGS Water Resources Data 1992-1997; Kann and Walker 1999). One of the earliest nutrient loading studies (Miller and Tash 1967) indicated that despite accounting for only 12% of the water inflow, direct agricultural input from pumps and canals account for 31% of the annual external total phosphorus budget. Other studies show that drained and diked wetland c consistently pump effluent containing 2-10X the phosphorus concentration of tributary inflows (Reclamation 1993a), and that nitrogen and phosphorus are liberated from drained wetland areas, leach into adjacent ditches, and are subsequently pumped to the lake or its tributaries (Snyder and Morace 1997). Coupled with the considerable but diffuse non-point contribution stemming from wetland loss, flood plain grazing, flood irrigation, and channel degradation, the TP input from anthropogenic sources likely accounts for a far greater percentage than that indicated by the 31% contributed due to direct pumping alone. Gearheart et al. (1995) estimated that over 50% of the annual TP load from the watershed could be reduced with management practices, and Anderson (1998) likewise estimated that in-lake TP concentration could be reduced by utilizing watershed management strategies. Walker (1995) also estimates that an increase in Agency Lake inflow concentration from 81 to 144 ug/l (40%) is an estimate of the anthropogenic impact.

In addition, there is evidence indicating that sediment regenerated P (internal loading) is also a large source of P in Upper Klamath Lake (Barbiero and Kann 1994; Laenen and LeTourneau 1996; Kann 1998). An important mechanism for release of phosphorus in shallow productive polymictic lakes is photosynthetically elevated pH (Welch 1992; Sondergaard 1988; Jacoby et al. 1982). Elevated pH increases phosphorus flux to the water column by solubilizing iron-bound phosphorus in both bottom and resuspended sediments as high pH causes increased competition between hydroxyl ions and phosphate ions decreasing the sorption of phosphate on iron. Evidence for this process exists in UKL where it was shown that the phosphorus associated with hydrated iron oxides in the sediment was the principal source of P to the overlying water, and that iron-phosphorus fractions decreased from May to June and July (Wildung et al. 1977). In addition the probability of achieving increased internal loading rates increases with pH, and it appears that about 9.3 is the pH level at which the probability of internal loading sharply increases (Kann 1998). Empirical evidence from Upper Klamath Lake along with supportive evidence from other lakes indicates that as the bloom progresses and elevated pH increases the flux of phosphorus to the water column, increased water column phosphorus concentration further elevates algal biomass and pH, setting up a positive feedback loop.

The Williamson River and Wood River together accounted for 67% (48% and 19%, respectively) of the 1992-1998 total phosphorus load; with springs, ungaged tributaries contributing another 10%. Precipitation, 7-Mile Canal and agricultural pumping accounted for the remaining 23% (Kann and Walker 1999). Unlike water contribution, where Wood River, 7-Mile, and Pumps contribute 25% of the water load, these same sources contributed 39% of the average annual TP load. In contrast, springs contributed 16% of the water input, but contributed only 10% of the TP load. This appears to be partially due to the consistently higher volume weighted TP concentration occurring in the pump effluent, and Wood River and 7-Mile canal systems.

The estimate of anthropogenic contribution of TP loading for all 7 water years is 40% with a range of 36 to 45% for individual years. These values are very similar to the 40% anthropogenic TP contribution estimated by Walker (1995) for Agency Lake.

TP loads during the 1992 and 1994 drought years were 62% of the 1992-1998 average. The 1993 water year is of note because while flow was 108% of the 7-year average, TP load was 114% of the average. Other years (with the exception of 1996) tended to have percentage of average TP loads lower than their respective percent of average water inputs. It may be that during several low water years (e.g., 1991 and 1992), watershed sources of TP accumulate, and are then flushed in a following high flow year. Moreover, the volume weighted TP concentration of the Sprague River in 1993 is higher than any other year, indicating additional watershed contributions of TP. Because the Sprague River watershed is impacted by wetland and riparian loss, flood plain grazing, agricultural practices, and channel degradation, it would be prone to TP export, especially during major runoff events.

An estimate of the particulate phosphorus (PP) load was taken as the TP load minus the SRP (soluble reactive phosphorus) load. These data clearly show an increase in the loading of PP during high runoff events for the Williamson and Sprague Rivers. During these high flow events, which typically occur from January-May, PP can increase to 60% of the TP load, compared to less than 5% during summer low flow periods. There are also noticeable spikes of PP load occurring in the Wood River and 7-Mile Canal systems, but they are not limited to high runoff periods. This pattern could be consistent with flood irrigation practices that would tend to be pulsed in nature, and where overland runoff could increase the proportion of particulates. The increase in PP loading are both indicative of degraded watershed conditions. In a healthier watershed (e.g., intact riparian areas and flood plains) the concentration should tend to decrease at high flows through dilution, and particulate loading should only increase slightly (Kann and Walker 1999).

Lake outflow TP load tends to increase during high runoff events in the winter and spring, as well as during the summer period when inflow load is low. It is clear from this trend, and the increase in lake TP storage (at a time when lake water storage is decreasing), that TP is being internally loaded from the sediments. This is confirmed by the large net internal loading occurring during late spring and early summer of each year. These large net internal loading events are generally followed by a substantial decline, indicating a large sedimentation event. Such events coincide with algal bloom crashes (Kann 1998). On average, external loading was 39% of the total loading to the lake, while internal loading was 61%. On an annual basis there tends to be a net retention of TP in the lake due to the significant sedimentation events from algal crashes and the likely settling of PP during high runoff (e.g., annual average retention is 25 metric tons). However, it is evident from the negative retention (positive internal loading) during the May through September period that internal loading is a significant source of phosphorus to the lake. Although there is a high contribution of internal TP loading to lake TP during algal growing season, it has been Noted that the mobilization of phosphorus from iron has the potential to respond rapidly when primary productivity and pH maxima are reduced (Marsden 1989). The rapid response may be due to a reversal of the positive feedback mechanism.

The total nitrogen balance indicates that UKL is a seasonally significant source of nitrogen. On an annual basis There is a net negative retention of TN (average annual negative retention is 143%). On a seasonal basis the range is between –259% and –627%. The main source for this increase in internal nitrogen loading is nitrogen fixation by the blue-green alga *Aphanizomenon flos-aquae* (Kann 1998). Another potential source is the mobilization of inorganic nitrogen from lake sediments during anaerobic bacterial decomposition.

4.4.1.31 Aquatic Vegetation Ecology

Detailed wetland vegetation mapping was conducted at Hanks Marsh by the National Biological Service (Salas 1995). This marsh is perched at elevations ranging from 4139 to 4140 feet. Wetland vegetation mapping of the large wetlands surrounding Upper Klamath Lake including Hanks, Squaw Point, Upper Klamath Marsh, Pelican Bay South, Agency Lake Ranch, and Wood River have been completed by Reclamation's Denver Technical Service Center using color infrared aerial photos (Lee Werth, Reclamation, per. com.). The Klamath Tribes contracted with Spatial Solutions, Inc. to map the fringe wetlands along the shoreline of Upper Klamath Lake in 1999 using ADAR remote sensing techniques (Klamath Tribes, unpublished data).

Reclamation has been collecting bathymetric data within the large wetland areas adjacent to UKL. The combined vegetation and bathymetric map layers can provide useful information on depth ranges for various species. PWA collected data on elevations where different aquatic plants were found in the Upper Klamath Marsh (PWA 1999). Western Milfoil (pondweed) was the deepest-rooted plant at approximately 4133, ranging up to elevation 4139. Pondweed, wocus and bulrush all generally had a deep rooting elevation at 4136 with upper rooting elevations at approximately, 4139, 4141, and 4141 respectively. In other locations around UKL bulrush extends to full pool elevation 4143.

Dunsmoor et al. (2000) documented substantial variability in aquatic vegetation depth distribution along the shoreline areas near the mouth of the Williamson River. These distributions were different than the larger wetlands adjacent to UKL (Reclamation, unpublished data). UKL operations undoubtedly affect the species composition, distribution, and abundance of aquatic plants in the lake and there is ample evidence both locally and in the literature that constant water levels (that fluctuate very little) would lead to losses in aquatic vegetation around UKL (i.e., Tule Lake, Lake Ewauna). Under pre-dam conditions UKL wetland communities were robust, under conditions in which lake elevations fluctuated approximately 2-3 feet annually. However, much of the historical shallow and gradually sloping marsh areas were diked and drained for agricultural use. Narrow fringe wetlands now exist over steeper slopes.

4.4.2 LINK RIVER

The Link River is a 1.7-mile long river that connects UKL with Lake Ewauna. Link River is a high gradient stream containing cascades or "falls". Historically, all the water leaving UKL flowed down the Link River. Now, much of the flow is diverted around the upper 2/3 of the river by two hydropower diversions operated by PacifiCorp. The diversions, one on each side of the river, originate at Link River Dam. The Westside diversion has a maximum capacity of 250 cfs; the Eastside 1200 cfs. Minimum release to the river is 90 cfs. The powerhouses are located about ¼ mile above Lake Ewauna.

The Link River is primarily a corridor for fish passing upstream from Lake Ewauna to UKL (primarily redband trout and suckers) or downstream through the fish ladder or spill gates during high runoff periods. PacifiCorp and ODFW conducted a fish passage study at Link River Dam from 1988-1991 (PacifiCorp 1997). Very few fish passed Link River Dam during the four-year study. The only year in which suckers were captured was 1989 a high flow year (18 adults). Low passage appears to be related to poor access through the cascades located about 600 feet below the dam, poor fish ladder design, lack of in-stream flows during spawning migrations, and small populations of migratory fish.

Sculpins and speckled dace appear to reside in this reach year-round. Juvenile and adult redband trout occupy Link River during all months except possibly July and August (Roger Smith, ODFW, per. com.). Other native and nonnative fish entrained through Link River Dam may also inhabit this reach for some unknown period of time.

Link River, because of its high gradient and numerous cascades, has a significant potential for oxygenation of water prior to entry into Lake Ewauna. Water quality in Lake Ewauna is frequently very poor in the summer months because of high biological oxygen demand and low DO concentrations. The lower Link River probably serves as a critical refuge for fish during periods of low DO. Howe ver, no studies have been conducted to verify this.

Reclamation recently completed a Link River Dam Fish Passage Project Scoping Report (Reclamation 2000e) that reviews fish passage studies, Link River spill termination fish salvage data, previous fish passage assessments, Eastside and Westside power canal salvage operations and Link River Dam entrainment studies.

4.4.3 KENO RESERVOIR

Keno Reservoir (Lake Ewauna and the upper Reach of the Klamath River above Keno Dam) is an impoundment 20 miles long by 300 to 2,600 feet wide; depths range from 9 to 20 feet (CH2M Hill 1996). Water surface elevations in this reach are controlled by Keno Dam between 4083 and 4086. Reservoir levels rarely fluctuate more than 6 inches seasonally, although the reservoir may be drawn down about 3 feet annually for 1-2 days to provide an opportunity for irrigators to conduct maintenance on their pumps and canals (PacifiCorp 2000).

Relatively little information is known about the fish resources in this reservoir (Hummel 1993, ODFW 1996). Limited monitoring indicates that tui chub, blue chub, and fathead minnows were the dominant species. Hummel captured six shortnose suckers ranging from 205 to 324 mm FL while ODFW captured a few Lost River suckers (size and number unspecified).

Summer water quality is generally poor, with heavy blue-green algae growth, high temperatures and pH, and low DO concentrations (ODFW 1996, CH2M Hill 1995, Reclamation unpublished data). Poor water quality in Keno Reservoir is associated with poor water quality entering from UKL, a high sediment oxygen demand (BOD), and a number of significant discharges with BOD (CH2M Hill 1996). This reach receives discharges from Klamath Falls and South Suburban sewage treatment plants, Columbia Plywood and Collins Products. In addition, irrigation return flows enter this reach from the Lost River Diversion Canal and the Klamath Straits Drain.

Reclamation has been collecting extensive water quality data in Keno Reservoir (Lake Ewauna to Keno Bridge) and Klamath Straits Drain since 1998. This data includes continuous Hydrolab information (temperature, pH, conductivity, redox, dissolved oxygen) from the Klamath Straits Drain (3-5 sites), Klamath River at Miller Island and Klamath River at Keno. Nutrients, metals, and other chemical parameters including alkalinity, turbidity, and chlorophyll-a have also been monitored from these sites at 2-4 week intervals. This data is being analyzed by David Evans and Associates and Mike Deas, consultants for Reclamation. Results of these analyses were not available for this BA.

4.4.4 KLAMATH RIVER RESERVOIRS

Sucker population status information for Klamath River reservoirs collected prior to 1996 was summarized in the 1996 BA (Reclamation 1996). In 1998 and 1999, OSU conducted a study of the distribution and biology of suckers in J.C. Boyle, Copco, and Iron Gate reservoirs for PacifiCorp (Desjardins and Markle 2000). Additional information on the fisheries in the Klamath River is summarized in PacifiCorp's First Stage Consultation Document (FSCD) for the Klamath Hydroelectric Project (PacifiCorp 2000).

Adult and larval suckers were found in all reservoirs in 1998 and 1999 (Desjardins and Markle 2000). All life history stages (larvae, juveniles and adults) were found in J.C. Boyle and Copco. The number of shortnose suckers was highest in Copco reservoir, followed by J.C. Boyle, and Iron Gate. Larger and older individuals dominated Copco and Iron Gate reservoirs and little size structure was detected. J.C. Boyle tended to have smaller adult shortnose suckers and many size classes were present. Unidentified larval suckers were most abundant in Copco reservoir where historic spawning of shortnose suckers has been documented. Larval suckers in Copco and Iron Gate reservoirs were most abundant in mid to late June before quickly disappearing from catches. J.C. Boyle larval suckers peaked in mid July, attained larger sizes, and were caught later in the season. It appeared that recruitment of age 0 suckers only occurred in J.C. Boyle with downstream reservoirs recruiting older individuals, perhaps those that had earlier recruited to J.C. Boyle.

Predation pressure may be somewhat reduced in J.C. Boyle in comparison to the other reservoirs as it's fish community was dominated by native fishes while communities in Copco and Iron Gate reservoirs were dominated by exotic predators. J.C. Boyle also possessed proportionally more littoral habitat, which suggests it may provide a more stable environment for young fishes. However, sampling was inadequate to demonstrate such relationships due to high variance in larval and juvenile catches and potentially confounding habitat variables. One such variable was water level fluctuations, which could interact with habitat and resource availability in complex ways. For example, water level fluctuations, presumed to have a negative impact were greatest in J.C. Boyle. Extrapolation from the literature suggests it should have had the poorest habitat for larval and juvenile suckers, but our results indicated J.C. Boyle had the largest number of young suckers.

River reaches between reservoirs include: Keno reach (3 miles between Keno Dam and J.C. Boyle Reservoir), Boyle reach (22 miles between J.C. Boyle Dam and Copco #1 Reservoir), and Copco #2 reach (1 mile between Copco #2 and Iron Gate Reservoir). Shortnose sucker spawning has been documented in the river above Copco #1 (Beak 1987). Sucker spawning is suspected in the Keno and Copco #2 reaches but has not been confirmed.

A review of Klamath River water quality studies is documented in PacifiCorp's FSCD document (PacifiCorp 2000). PacifiCorp has collected water quality data from Klamath River reservoirs for the last couple of years (PacifiCorp 2000). This data includes Hydrolab profiles, nutrient concentrations, and other parameters. Mike Deas, a private consultant, is using some of this data to model water temperature, pH, dissolved oxygen and nutrients in Iron Gate to assist with water operation planning for Klamath River releases for anadromous fish.

4.4.5 CLEAR LAKE

A biological assessment of restricting the elevation of Clear Lake Reservoir to meet Safety of Dams guidelines was completed on September 30, 1999 (Reclamation 1999b). On August 18, 2000 Reclamation requested re-initiation of formal consultation in accordance with Section 7 of the Endangered Species Act associated with a proposed action to release additional water in August and September 2000. These documents review the new scientific information collected since the 1994 biological opinion.

4.4.6 GERBER RESERVOIR

Reclamation conducted water quality monitoring at Gerber Reservoir from October 1991 to December 1994 (Reclamation, unpublished data). Temperature, dissolved oxygen, pH, and conductivity were monitored using Hydrolab Inc. instrumentation. Continuous data was collected near the dam at 1meter below the surface. Instantaneous profile data was collected at up to 8 sites around the reservoir.

In 1992, an extremely low lake level year, low dissolved oxygen conditions were documented during the summer months. Most values ranged from 4-6 mg/l throughout the water column. In June 1992, DO reached a low of 1.1 mg/l at the bottom near the dam and readings less than 4 mg/l were recorded from May through mid September. In the fall, DO concentrations increased continuously as water temperatures decreased. pH values ranged from about 7.2-8.2. These relatively low pH values were probably related to high turbidity and lack of phytoplankton growth. Turbidity readings of 160-300 NTUs were recorded with Secchi disk transparencies of less than 0.5 m. Conductivity increased throughout the year, beginning about 140 uS/cm in March and increasing to 210-230 in the fall months. This increase was associated with decreasing water levels mostly due to lake evaporation.

In 1993, a wet year with relatively high lake levels, water quality conditions were much better than 1992 (Reclamation, unpublished data). Conductivity readings dropped from about 200 uS/cm in January to 50 by March. Conductivity reading throughout the rest of the year ranged from 50-70 uS/cm. pH values increased from 7.2-7.6 in January to 9.0-9.5 during July and August. High values were associated with phytoplankton blooms during the summer near the surface (at least the top 5 m). Lower pH values (6.8-8.0) were monitored near the bottom at the dam. With the large inflow of water during the late winter and spring, water transparencies improved dramatically. Turbidity readings dropped from about 200 NTUs to 10-25 NTUs except during algae blooms. DO concentrations were low during January and February associated with ice-cover conditions. Reading were ranged from 3-6 mg/l in the top several meters and as low as 1.5 mg/l near the bottom. During the thaw and major runoff period in mid to late March, DO increased to 9-10 mg/l. DOs during the summer were relatively high and variable in the surface waters associated with algal bloom activity. Bottom DOs dropped throughout the summer and early fall. In June readings were 7-8 mg/l and dropped to less than 2 mg/l in August-October. This change was associated with stratification of the lake. Water temperatures were 3-5 C colder at the bottom than the surface. Water quality conditions were generally similar in the top 3-5 m of the water column.

Water quality conditions in 1994, which was a low reservoir level year, were similar to 1993. In January and February during ice-cover conditions DO concentrations were relatively high in the upper 5-8 m (6-11 mg/l) and decreased to less than 1 mg/l at the bottom. Algae blooms occurred in July and August influencing pH and DO conditions. DOs remained above 4 mg/l in the top 3-5 m. Lower DO concentrations were recorded at deeper depths during July and August.

Reclamation monitored fish populations in Gerber Reservoir from April 1992 to June 1996. Trap nets and trammel nets were used to monitor fish on 6, 10, 16, 4, and 2 dates in 1992, 1993, 1994, 1995, and 1996 respectively (Reclamation, unpublished data). A total of 597 suckers > 275 mm FL were captured during these five years. Sucker catches (fish > 275 mm FL) by year from 1992-1996 were 199, 60, 288, 12 and 28 respectively. All larger suckers were tagged with either a floy anchor tag or PIT tag and released. Only one fish was recaptured (1995). Total sucker catches for 1992-1996 were 217, 160, 615, 14 and 28 respectively.

Most suckers collected ranged from 300-530 mm FL. However, the majority of the sampling effort was based on large mesh (2 inch stretch) trap nets and trammel nets. On several occasions, small-meshed (1 inch stretch) trap nets were used and many smaller-sized fish were captured (70-275 mm FL). Ages of 44 suckers, 30 of which were adults collected for genetic studies and the remainder mortalities from salvage operations below Gerber Dam documented 10 different year-classes. Fish ranged from 2-14 years old.

Shortnose suckers captured in 1992 and spring 1993 were very thin compared to shortnose suckers from Clear Lake, Tule Lake and Upper Klamath Lake. Extremely low water levels, high turbidity, and low DO concentrations may have contributed to their poor condition. In contrast, suckers captured in 1994-1996 (years with better water quality and higher lake levels) were substantially more robust. For example, using a linear regression analysis a 400 mm FL fish in 1992 would weight about 600 grams compared to about 800 gram in 1994. A 500 mm FL fish's weight would be about 1500 grams in 1994 compared to 1200 grams in 1992.

Sucker salvage operations were conducted below Gerber Dam in 1992, 1993, and 1997. In 1992, 229 suckers were captured and relocated to Gerber Reservoir. They ranged from 78 to 461 mm FL with considerable representation at sizes from 125 to 400 mm FL. In 1993 34 suckers were collected below the dam including about 20 age 0 suckers. Salvage operations in October 1997 as part of a Safety of Dams evaluation captured 152 suckers ranging from 80-470 mm FL. Most fish were 150-260 mm FL.

The Bureau of Land Management (BLM) has conducted spawning surveys in Gerber Reservoir tributaries from 1993-1999 (BLM 2000). Visual observations were made at specific locations over the course of a few dates each spring. The streams surveyed included Wildhorse, Ben Hall, Long Branch, Pitch Log, Barnes Valley, and Miller Creeks. Spawning migrations were documented in Barnes Valley Creek for all years. One year, 1994, was likely a poor success year because stream flows were very low and of short duration. No spawning or documentation of larvae was observed in Wildhorse Creek. A rock falls near the inlet to Gerber Reservoir seems to be impassable. Sucker larvae were found in Ben Hall Creek in 1993, 1995, 1996, 1998, and 1999. Long Branch and Pitch Log Creeks, tributaries to Barnes Valley Creek had evidence of sucker spawning in only 2-3 years.

The timing and duration of flow events are highly variable in the Gerber Reservoir tributaries. Successful reproduction appears to be dependent upon coincidence of runoff events and spawning readiness (A. Hamilton, BLM, per. com.). Spawning usually occurred during periods of rapidly dropping hydrographs. All streams are reduced to isolated pools or very low flows by the end of May.

Juvenile suckers were observed in Long Branch, Barnes Valley, and Miller Creeks that indicates some degree of stream residency. Adults appear to be frequently stranded in receding flows but few probably survive in the small stranded pools.

Another Gerber tributary, Barnes Creek is a small tributary that does not support sucker spawning. This stream is seasonally dammed for irrigation and stock water purposes. Dry Prarie Dam located on Ben Hall Creek prevents passage to upstream spawning habitat during some years depending on the flows and the timing of the placement of dam boards. A concrete road crossing located in the lower portion of Barnes Valley Creek appears to restrict passage under low flow conditions. BLM replaced the crossing in September 2000.

4.4.7 LOST RIVER

Reclamation monitored sucker populations in the Lost River on a few occasions in 1992. Approximately 100 shortnose suckers were observed at Big Springs in Bonanza on April 7 and 8, 1992. Thirteen were captured ranging from 378 to 490 mm FL. Four spawning sites were identified in the springs. Water depths at spawning sites ranged from 1.2 to 2.4 feet and bottom substrate consisted mostly of gravel and small cobble. Water quality at the spawning areas included: water temperature 16.3-16.5 C, pH 8.0-8.1, dissolved oxygen 7.3-7.8 mg/l, and conductivity 157-158 uS/cm. Sucker eggs were observed in the substrates. About 4 weeks later hundreds of sucker larvae were observed in the springs.

On April 13, 1992 four trap nets (1-inch stretch) were set overnight in the Lost River between Malone Dam and Keller Bridge in the Langell Valley area. No suckers were captured in this shallow low gradient channelized river section that averaged about 2 feet deep. Very little flow was documented in this reach and no water was being released from Malone Reservoir. On April 14, an electrofishing survey was conducted from Keller Bridge to Bonanza using a boat electrofisher. Ten adult suckers were captured and about 10 additional fish were seen but not collected. Most suckers were sampled from deeper pools about 2-4 miles below Keller Bridge.

On September 16, 1992 trap nets were set overnight in the Lost River just above Harpold Dam, 0.2 miles above Big Springs and approximately 0.5 miles above Big Springs. Three adult shortnose suckers were captured at the site 0.2 miles above Big Springs.

Four trap nets were set overnight in Malone Reservoir on the Lost River, at the upper end of the Langell Valley on July 30, 1992. Two adult shortnose suckers, 371 and 430 mm FL, were captured.

On April 26, 1995 seven juvenile suckers were captured in the Lost River adjacent and downstream of Big Springs using a backpack electrofisher. These fish ranged from 122 to 232 mm FL. One adult shortnose sucker 484 mm FL was captured and radio-tagged.

Trammel nets were fished for 2-5 hours in Wilson Reservoir, at the confluence of Miller Creek, Keller Bridge, and Harpold Road below Big Springs on May 23, 1995. One adult shortnose sucker, 384 mm FL was captured near Big Springs and radio-tagged. Another shortnose sucker, 410 mm FL was captured and radio-tagged at Wilson Reservoir.

On May 26, 1995 four trammel nets were fished for 3-4 hours in Wilson Reservoir. Eight adult shortnose suckers were captured ranging from 400 to 468 mm FL (all females). One sucker 468 mm FL was radio-tagged.

Reclamation tracked the four radio-tagged suckers at 1-2 week intervals throughout the summer. The two Wilson Reservoir suckers remained in the reservoir. One of the Big Springs area fish was located about a mile upstream of Big Springs on May 24, 1995. Over the next two weeks it was located in the Lost River near Buck Creek. By July 19 it was located just downstream of Big Springs where it remained into August when monitoring stopped.

One trammel net were fished overnight in the Lost River near Buck Creek on October 10, 1996. Three shortnose suckers (310, 317, and 478 mm FL) were captured. Two trammels were fished in the same area for about 2 hours during daytime on October 11 with one shortnose sucker, 302 mm FL, captured.

In 1999, Reclamation and BRD conducted a more detailed fish monitoring effort on the Lost River and selected tributaries from June 11 to October 5 (Shively et al. 2000b). Adult suckers were captured throughout the river system although the majority of suckers were captured in the Harpold reach above Harpold Dam. A total of 105 suckers (>250 mm) were captured. Only one Lost River sucker was captured while the remainder were shortnose suckers. Based on length frequency distributions it appears that several year classes were represented within the Lost River. Juvenile suckers were also captured throughout the Lost River. Most juveniles were captured in the Harpold Reach, Keller Bridge, and the confluence with and within Miller Creek.

Reclamation continued fish monitoring in the Lost River from March-June 2000 (Reclamation, unpublished data). Adult suckers were captured throughout the Lost River with the majority captured in the Harpold reach and Wilson

Reservoir as was noted in 1999. Very few fish were captured between Wilson Reservoir and Anderson-Rose Dam.

Spawning habitat in the Lost River is very limited. Sucker spawning has been documented below Anderson-Rose Dam, Big Springs, and at the terminal end of the West Canal as it spills into the Lost River. Suspected spawning areas that have suitable habitat (rocky riffle areas) include the spillway area below Malone Reservoir, just upstream of Keller Bridge, just below Big Springs, just below Harpold Dam, and adjacent to Station 48. Spawning has also been documented in a Lost River tributary (Miller Creek) and is suspected in Buck Creek. Several adult suckers were captured near the mouth of Buck Creek in June and juvenile suckers were captured in Buck Creek.

Twenty-four adult suckers were implanted with radio-tags between April 28, 1999 and May 6, 2000. They included 14 females, 9 males, and 1 unknown sex. They were radio-tagged and released at six locations on the mainstem Lost River and Miller Creek. Four were caught in Miller Creek on April 28, 1999. These suckers moved out of Miller Creek during May and resided in the Lost River between Keller Bridge and Big Springs through September 1999 when tracking ceased. On April 20, 2000 one of the tagged fish was located below Big Springs Dam.

Three suckers were caught between Harpold Dam and Big Springs Dam on May 26, 1999. All three stayed in this reach through September 1999. The last date a fish was located was June 16, 2000. In 2000, three suckers were caught at the mouth of Buck Creek on May 4, 2000. These fish appeared to be in a post-spawning condition. They all stayed in the reach between Harpold and Big Springs Dam until August 18, the last date fish were tracked.

In spring 2000, three adult suckers were implanted with radio tags and released in the Lost River reach between Lost River Ranch Dam and Harpold Dam. Two of these fish have stayed in this reach until August 18, and one fish has not been located since June 9. It is not clear whether these fish spawned in the mainstem Lost River. Boards at Harpold Dam were put into place in late April and may have prevented upstream movement of the fish.

Three suckers were captured in Wilson Reservoir and implanted with radio tags on March 22, 2000. By April 5 two fish had moved upstream of Wilson Reservoir into a narrower section of the Lost River. All three were upstream of the reservoir on June 2 and stayed there at least until July 20. None of these fish entered into tributaries during the spawning season and passage was blocked at the Lost River Ranch Dam during late April, possibly prohibiting upstream movement of these fish.

Two suckers were captured below Wilson Dam on April 4 and April 13, 2000. Both fish remained in this reach until July 20, the last date of tracking.

Reclamation has conducted water quality monitoring at up to 17 locations in the Lost River between Malone Dam and Tule Lake from 1992 to the present. Between 1992-1998, biweekly to monthly profile data was collected using Hydrolab water quality instrumentation that measured temperature, dissolved oxygen, pH, and conductivity. Reclamation has also collected more detailed water quality information quarterly at Anderson Rose Dam and Wilson Reservoir since 1980 and twice a year (May and August) at Malone Reservoir and Miller Creek Dam. Water quality constituents included: air temperature, water temperature, dissolved oxygen, pH, conductivity, ammonia, nitrate + nitrite N, orthophosphate, total phosphorus, Kjeldahl nitrogen, total dissolved solids, alkalinity, boron, mercury, turbidity and arsenic.

Beginning in May 1999, Reclamation expanded its' water quality monitoring program in the Lost River subbasin to provide more detailed baseline information on selected water quality parameters on both a seasonal and spatial scale. Water quality sampling is proposed to continue through May 2001. Sampling occurs every two weeks at 13 sites along the course of the Lost River. Parameters include temperature, dissolved oxygen, pH, conductivity, turbidity, Kjeldahl nitrogen, ammonia, nitrate-nitrite nitrogen, total phosphorus, orthophosphate, alkalinity, and chlorophyll-a.

A detailed analysis of this data has not been completed. Water quality data collected in 1999 is summarized in Shively et al. (2000b).

4.4.8 MILLER CREEK

In 1999, substantial numbers of adult suckers were observed in the lower portion of Miller Creek (below East Langell Valley Road). Twenty-one shortnose suckers were captured using a backpack electrofisher and about 20 additional suckers were observed but not captured on April 28. Suckers ranged from 338-474 mm FL and included 18 males and three females. All suckers were ripe. On April 29, another 15 adult shortnose suckers were sampled and/or observed from Miller Creek above the Wooden Bridge approximately 1mile upstream of the confluence of the Lost River.

On May 4, 12 suckers were collected from several sites sampled between East Langell Valley Road and mouth of Miller Creek. Small numbers (<10) of adults were observed through May 26.

Sucker eggs were documented at several riffle areas in Miller Creek from East Langell Valley Road to the mouth on May 4. On May 20, sucker eggs were found at two riffle sites below the Wooden Bridge. Seven groups of larval suckers containing about a dozen fish each were observed in the backwater areas. Three locations with suitable gravel above the Wooden Bridge were checked for sucker eggs and none were found. No larvae were observed in this section. However, sucker larvae were common throughout the reach from East Langell Valley Road to the mouth on May 25.

Few observations were made above East Langell Valley Road and none above Miller Creek Dam during the 1999 sucker spawning run. A rock and cobble check dam on private property downstream of the diversion dam may restrict or block upstream passage. On May 25 visual observations in backwater areas in North Canal failed to document any sucker larvae. But, larvae were found just below East Langell Valley Road on this date. Young-of-the-year juvenile suckers were observed throughout the year in lower Miller Creek. On May 17, 2000 dozens of juvenile suckers, 40-80 mm FL were sampled from the Willow Hole about 0.5 miles upstream from the mouth.

The sucker spawning run in Miller Creek appears to have been stimulated by the controlled release of water (470-490 cfs) from Gerber Reservoir between February 17 and April 23, 1999 to minimize the risk of flooding. In 2000, no water was released from Gerber Reservoir prior to irrigation season and suckers were not observed spawning in Miller Creek. Flows in lower Miller Creek ranged from approximately 5-10 cfs during the spawning season (March – May). At these lower flows, passage may be restricted by the shallow water depths (2-3 inches) at the mouth of Miller Creek. During late spring and summer passage improves as water levels in the Lost River increase due to agriculture return waters in the Lost River and aquatic plant growth. Spawning access may be improved through constriction of the stream channel at the mouth. Suckers have been seen spawning in the lower reaches of Miller Creek for the last 8-10 years by local landowners (Dave McCarley, LVID, per. com.).

4.4.9 OTHER LOST RIVER TRIBUTARIES

On July 19, 1999 Reclamation sampled the East Branch of the Lost River and Rock Creek using a backpack electrofisher. No suckers were captured from the lower reaches. However, juvenile suckers have been previously collected from the East Branch in 1990 (Buettner and Scoppettone 1991). BRD collected age 0 juvenile suckers in Buck Creek near Bonanza in the summer of 1999 (Shively et al. 2000b).

4.4.10 TULE LAKE

Reclamation has monitored endangered sucker spawning runs from Tule Lake into the Lost River yearly since 1991 (Reclamation 1998c). Relatively small runs of Lost River and shortnose suckers have migrated upstream in late April and May each year and spawned at the base of Anderson Rose Dam. In 1995, Reclamation constructed a spawning channel below Anderson Rose Dam and added gravel to a known spawning riffle. The spawning channel did not appear to be used although fish were observed in it. In 1996, the channel washed out under high winter flows. The channel was not rebuilt.

Although dozens of suckers were observed spawning during May each year and eggs found in the substrate, substantial numbers of larval suckers have only been observed in 1995. However, since no intensive larval emigration sampling has been conducted it cannot be concluded that spawning was a failure each year except 1995. However, we believe that enough visual observations were made during most years to detect good larval sucker survival.

Water quality parameters including temperature, dissolved oxygen, pH, and conductivity were monitored continuously during the 1995 and 1996 spawning seasons. These water quality parameters were adequate for sucker spawning and incubation (Reclamation 1998c). Relatively high concentrations of ammonia have been monitored in this area that may contribute to the low survival (Reclamation, unpublished data).

Beginning in 1999, Reclamation changed operations in the Lost River below Anderson Rose Dam. Specifically, releases of 30 cfs were started on April 15 and continued until spawning and incubation were complete in early June. Previously, releases of 50 cfs were required beginning April 1 and continuing for at least four weeks (1992 BO). Observations in 1995, 1999, and 2000 by Reclamation biologists show that releases of 30 cfs may be adequate for sucker passage and spawning. In 1999, suckers began migrating to Anderson Rose Dam as early as two days after releases were started. In 2000, the first suckers were observed April 21, 6 days after the April 15 start date.

In 1994, the U.S. Fish and Wildlife Service attempted to collect transect data for physical habitat simulation modeling (PHABSIM) but stopped after they found that a backwater effect influenced the river's water levels. It appears that aquatic plant growth in the river is a major factor effecting water levels. This growth increases throughout the spring leading to greater resistance to flow and higher water levels. Tule Lake sump elevation and agricultural return flows below Anderson Rose Dam also affect river water levels.

Reclamation conducted water quality monitoring from 1992-1995 and radio telemetry studies of adult shortnose and Lost River suckers from 1993-1995 at Tule Lake (Reclamation 2000c). Five adult Lost River suckers and five adult shortnose suckers were captured in Sump 1A, radio-tagged, and released in April 1993. Lost River and shortnose sucker movements were similar throughout the study period with both species intermixed. Fish moved from the English Channel where they were tagged to a localized area in the south central portion of 1A ("Donut Hole"). They remained there until late October when they began dispersing and concentrating in the northwest corner. They remained there through the winter. In April 1994 they again moved to the English Channel. Movement patterns were the similar in 1994 as in 1993.

Radio-tagged Lost River and shortnose suckers remained in Sump 1A throughout the study (Reclamation 2000c). Their use of Sump 1A may be related to better water quality conditions that generally occurred there compared to Sump 1B. The most important water quality parameters seemed to be pH and dissolved oxygen. Potentially stressful and lethal levels of high pH (>10.0) were much more common in Sump 1B than Sump 1A. Sump 1B also had more potentially stressful DO conditions than 1A. Both species of suckers concentrated in a small area of 1A during the summer months. DO and pH values were less variable there than other water quality sampling sites in 1A and 1B. DO rarely dropped below stressful levels of about 4.0 mg/l and lethal levels (<2.0 mg/l) were absent. pH rarely exceeded stressful levels at this site. The "Donut Hole" was unique in that rooted aquatic plant growth was low and the water was frequently quite turbid compared to other sites during the summer. The bottom substrate was firmer and composed of clay and other inorganic sediment particles compared to the softer organic peat substrates found elsewhere.

Adult suckers were generally located in water depths greater than 0.8 m. The area of Sump 1A that is this deep and greater is small. There is also evidence that both sumps have filled in substantially over the last several decades due to sedimentation (Hicks et al. 2000).

In 1999, another water quality monitoring and sucker telemetry study was conducted at Tule Lake (Hicks et al. 2000). Eleven adult Lost River suckers and four adult shortnose suckers were radio-tagged during April and May. In April and May most suckers congregated in the English Channel with a scattering of fish located elsewhere in 1A. From June through September nearly all suckers were found in the "Donut Hole". From September - December suckers moved to the northwest corner of Sump 1A. These movement patterns were similar to those of adult suckers tracked during 1993-1995 (Reclamation 2000c). Water quality parameters, DO and pH, were less variable and did not reach the extremes that were documented at other sites during the summer months.

Very few of the radio-tagged suckers migrated up the Lost River during the spawning season. None of the 10 suckers tagged in 1993 migrated upstream in 1994. In 1999, one of eight Lost River sucker tagged in Tule Lake migrated upstream to Anderson Rose Dam. In 2000, two out of 14 suckers migrated. The low rate of river use may be related to higher mortality risk associated with shallow depths and low flows in the Lost River during spring, lack of imprinting, and stress related to capture and radio-tagging.

Fish population monitoring in Tule Lake was conducted by the National Biological Service from 1992-1994

(Scoppettone et al. 1995). Approximately 60 shortnose suckers and 60 Lost River suckers were captured with trap nets during the study. All fish were tagged and released. Population estimates for 1993 were based on fish captured and marked in 1993 and recaptured in 1994. The estimated number of shortnose adults was 159 with 95% CI of 48 to 289. Only 105 Lost River suckers were estimated with confidence intervals ranging from 25 to 175.

Adult suckers captured in Tule Lake had fewer external parasites and were larger and heavier than suckers from Clear Lake and Gerber Reservoir. No lamprey parasitism was observed.

In 1999, trammel nets were set on two occasions, April 2 and 9, in the Northwest corner for 1-2 hours. On April 2, seven Lost River and two shortnose suckers were captured from five nets. On April 9, three shortnose and two Lost River suckers were captured from 7 net sets of 1-2 hours. One shortnose sucker originally tagged in 1993 was recaptured.

On April 7, 2000 the Service (Klamath Basin National Wildlife Refuges) set 3 trammel nets in the Northwest corner and 2 nets in the English Channel for 2-3 hours. Five Lost River suckers and 11 shortnose suckers were captured in the northwest corner and six Lost River suckers and four shortnose suckers were captured in the English Channel. Two of the Lost River suckers were fish marked in previous years.

Based on spawning run observations at Anderson Rose Dam and recent sucker monitoring in Tule Lake to capture adults for the radio telemetry studies, it appears that the adult populations of Lost River and shortnose suckers are larger than those estimated in 1994. Between 1993 and 2000 Reclamation tagged and released 91 Lost River suckers and 14 shortnose suckers below Anderson Rose Dam. In 1995, two of 9 Lost River suckers were tagged in 1993. In 1999, one out of 17 Lost River suckers captured was a recapture from 1993 and in 2000 seven Lost River suckers were previously tagged fish (40 captured). It appears that there may be several hundred adults of both species.

4.4.11 LOWER KLAMATH LAKE

Lower Klamath Lake, for the purposes of this BA is considered the major permanently flooded unit of the Lower Klamath Lake NWR (Unit 2). This 4,500-acre marsh represents the last vestige of the historic marsh in the Lower Klamath Lake area and remains connected to the Klamath River by the ADY Canal. Juvenile suckers were captured near the inlet of the ADY Canal in 1988 (J. Hainline, per. com.). No suckers were captured in a 1990 fish survey of the lake (Buettner and Scoppetone 1991). Because water depths are generally less than 3 feet, adult sucker habitat is lacking. It appears that larval and juvenile suckers occasionally enter the lake from the Klamath River.

5.0 ENVIRONMENTAL BASELINE

The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal consultation, and the impact of State and private actions which are contemporaneous with the consultation process. Since Reclamation is proposing continuing operation of the Klamath Project consistent with historic operations, we believe this action can be considered the environmental baseline. Reclamation is also developing a long-term operations plan. Depending upon how operations are modified, these effects will be added to the baseline in a future section 7 consultation.

6.0 EFFECTS OF KLAMATH PROJECT ON BALD EAGLES

Bald eagles are dependent primarily on waterfowl and fish for food. Therefore the manipulation of the timing and amount of water available across the landscape of the Upper Klamath Basin (which is largely controlled by the Klamath Project) directly and indirectly affects the survival and recovery of bald eagle populations. The effects of the proposed action can be broken into three categories: effects to nesting bald eagles, effects to wintering bald eagles and effects to non-nesting summering eagles.

6.1 Nesting

The Klamath Basin contains approximately 25% of the nesting bald eagles in Oregon and the Washington portion of the Columbia River Recovery Area. Nests are widespread in the Basin. They are found on or near Upper Klamath Lake, Gerber Reservoir, J.C. Boyle, Klamath River and the Lost River. Because they are dependent on water bodies for food supply most of these nesting pairs could be affected by the proposed action.

Prey availability influences eagle reproductive rates, because the pre-breeding condition of a female eagle determines its ability to produce eggs and because food must be available not only for the adults during nesting but also for their young. Thus, bald eagles must obtain enough food during the winter to come into breeding condition in early spring, support 5 weeks of incubation, and provide food to nestlings and fledglings for about 4 months. Lack of food at various points in the breeding cycle may inhibit nesting attempts, cause abandonment of the nesting effort, or result in starvation of young.

Reproductive rates are also subject to several secondary variables, including weather, contaminants, and disturbance factors, but prey availability and the availability of nesting habitat near food resources are believed to be the primary limiting factors for these eagle populations. Prey become available to bald eagles in two ways: 1) when the behavior of a live individual prey item makes it available for capture, such as a fish basking or feeding near the water surface or spawning in shallow water; or 2) when the carcass of a dead individual is available on the ground, on ice, in shallow water, or floating at the water surface. Only a portion of available prey is actually discovered and taken before it becomes unavailable. The number of available prey items is, therefore, a function of prey population size, expressed through prey behavior and mortality rates.

No bald eagle breeding territories are known from the area around Clear Lake. Eagles that nest in nearby areas and birds moving through likely forage at the lake. With the expanding population of eagles in the Klamath Basin and limited foraging territories, it is possible that eagles may attempt to establish a foraging territory near Clear Lake. Water manipulation of the lake would directly affect fish populations and indirectly could affect any eagles that utilize the foraging opportunities provided by the lake. Reclamation's proposed action for Clear Lake should protect fish populations during all water year types. Foraging is likely to be better during low lake operations when depths are shallower and fish are more concentrated. When the reservoir expands during wet years, fish densities will be lower initially making foraging potentially more difficult. Productivity may be reduced during years of reservoir expansion.

There were two nesting territories at Gerber Reservoir in 1992. There are presently four nesting territories in the area. The increase is likely the product of the increasing number of eagle pairs in the basin and the possible "packing" of available habitat. The reproductive rate of these nesting territories has been considerably lower than the rate of 1.0 young per occupied site per year recommended by the Pacific Bald Eagle Recovery Plan. This condition may be influenced by competition for a limited forage resource. The nests were monitored in 1992 because of concern over the effects of the low reservoir levels. Also, a supplemental feeding program for the eagles was considered but not implemented. However, eagles failed to produce young in that year.

Reservoir draw-downs during dry years may result in temporary increases in prey availability if reduced habitat causes increased concentration of fish populations and/or higher fish mortality rates. If more dry years follow, lake levels will remain low and fish populations may continue to decline or stabilize at a lower level. During 1992, there was no indication that fish die-offs occurred. However, fish including the endangered suckers showed signs of stress and reduced growth that may have made them more vulnerable to predation. In subsequent years when lake levels rise, fish become dispersed into increasing habitat. It may take a couple of years for fish populations to respond to increasing habitat as the reservoir rises. In either case, forage availability is expected to be lower for some time following periods of large draw-downs, and this may in turn result in lower reproductive rates among the resident bald eagles.

The last 6 years of high reservoir elevations combined with the recovery of bald eagles in the basin may have contributed to the establishment of the two additional territories in the Gerber Reservoir area. One was established in 1996 and the other in 1997. With 4 nesting territories, there is an increased likelihood of an adverse impact when the reservoir is managed at lower levels. While initially the eagles might find foraging easier for stressed and more concentrated fish, eventually the fish populations would drop and might take a few years to recover to previous densities. Another direct impact of lower reservoir levels come through the foraging territories of each nesting pair becoming smaller and with less buffer area between them as the water recedes from shorelines. Monitoring by the BLM on the eagles in the summer of 1991 and 1992 identified two distinct foraging areas specific to nesting eagles.

That report raised just such concerns even at the lower territory level present in 1992. There are also several ospreys that nest and forage on Gerber Reservoir and compete with bald eagles for food. The proposed action with large draw-downs occurring during below average, dry and critical dry years may lead to low nesting success at Gerber Reservoir and possibly a temporary abandonment of nesting territories during a few years. However, adequate lake levels are likely for most years increasing the probability of nesting success.

The bald eagles nesting at Upper Klamath Lake are less likely than other territories to be adversely affected by the proposed action. Draw-downs are much less than other Project reservoirs and therefore there is less potential for competition for food by nesting eagles. Eagle reproduction at UKL has been within the normal range during the past several years. The Upper Klamath NWR contains much of the foraging habitat for nesting eagles. Lake level management over the last several decades may have encouraged the proliferation of hardstem bulrush (J. Hainline, per. com). This proliferation has resulted in a loss of shallow open water for foraging. This reduces overall foraging areas and may push eagles into channels used more heavily by recreationists. This would reduce foraging success and increase energy needs. Diking and draining of thousands of acres of marsh for conversion to agriculture around UKL in the last century also has had a significant negative affect on eagle foraging.

Reclamation purchased the 7,100-acre Agency Lake Ranch, adjacent to Upper Klamath NWR, in 1998 and has operated it in a manner that has allowed shallow marsh habitat to develop. Eagles have been observed foraging at the ranch throughout the year. Prior to 1998, the Ranch was operated as a cattle operation. Wetland restoration projects are underway at Tulana Farms, Running Y Ranch, and Wood River Ranch. These projects are likely to benefit bald eagle nesting and foraging through by attracting waterfowl. Because bald eagle productivity at UKL has been within the normal range in recent years, the proposed action may not adversely affect eagle nesting success.

Two to eight nesting pairs of bald eagles forage in the Tule Lake and Lower Klamath Lake NWRs. Water availability should be adequate during all water year types to support permanent and seasonal wetlands during the spring and summer months.

6.2 Wintering Eagles

The wintering population in the Klamath Basin is one of the largest winter concentrations of bald eagles in the lower 48 states with peak counts from the mid 1980's through the 1990's ranging from 200 to 1000 eagles. Wintering areas and the eagles that use them are very important to recovery and long-term maintenance of the species. The majority of the birds that winter in the Basin are not local birds but are from many western states and Canada. Therefore, impacts to the wintering birds are not just a local impact but a significant regional one.

One of the keys to that stability is feeding areas. The primary prey base for wintering eagles in the Klamath Basin is waterfowl; especially crippled birds and those weakened or killed by avian cholera. Small mammals become important as agricultural lands are flood irrigated in the winter. Irrigation return flows from the Klamath Project eventually reach the Tule Lake NWR and Lower Klamath Lake NWR, providing seasonal habitat for millions of migratory waterfowl. These waterfowl provide the primary prey base for hundreds of migratory eagles wintering in the Basin each year. Eagles come from a wide area to escape harsher conditions and feed on the concentrated food source juxtaposed with rooting habitat.

Lower Klamath NWR is subject to the vagaries of water availability. If water is not available to flood up Lower Klamath NWR in the fall, waterfowl do not use the area in great numbers and the eagles are forced to spread out in the region, away from preferred roosts and concentrated food sources. In the winter of 1992-1993 waterfowl numbers were low in the Basin due to a lack of open water areas caused by an extremely cold weather. Wintering eagles were seen feeding on roadkills and nearer to human activity.

The small mammals made available by early field flooding in the agricultural areas can also be affected by availability of water and farming practices of many separate private landowners. For example, in recent years private farmers in the Lower Klamath Lake area have flooded their fields in the fall rather than winter out of concern that water deliveries may be shut off by Reclamation. These deliveries have coincided with refuge flood up operations resulting in competition for limited water and delivery capacity. Early pre-irrigation on private lands may lead to flood-up before most wintering eagles arrive. Also waterfowl are attracted to open water areas during irrigation. If irrigation is completed in the fall, there would likely be less open water during the winter. Dependence on unnatural food sources has been demonstrated to put scavengers like bald eagles at greater risk. Adequate water to support eagle prey management may be important to wintering populations since there are so few areas that have adequate food and roosting habitats.

Reduced water deliveries to the Lower Klamath NWR may significantly affect the quantity and quality of habitat for migratory waterfowl. Some direct effects on wintering eagles may be anticipated; however, the magnitude of such effects cannot be easily predicted with existing information. Food stress caused by lower prey populations may force portions of the wintering eagle population to spread out into sub optimal wintering habitats. An unknown number of eagles may starve and an unknown number of adult eagles may have lower condition at the beginning of the breeding season. The lowered health of the wintering population directly affects their ability to reproduce successfully both here in the basin and in territories in other western states and Canada. The proposed action would likely lead to adequate deliveries of water to Lower Klamath NWR supporting waterfowl and wintering eagles that prey on them.

6.3 Non-breeding Immature, Sub-adults and Adults

The Klamath Basin is known to provide summer and winter habitat for non-breeding eagles from other areas throughout the Pacific Northwest, western states and Canada. Very little is known about the summer feeding strategies of these eagles in the Basin. Due to the dominance of territorial mated pairs, immatures, sub-adults and non-breeding adults likely have much reduced opportunities for foraging. In winter access to large populations of waterfowl that are easily accessible is important to inexperienced immatures because of the ease of capture and proximity to winter roost areas.

In summary, while the proposed action may adversely impact nesting eagles during some years (when lake levels are low or increasing), the probability of good nesting success should be good in most years. Water management activities are likely to provide adequate supplies of water to support the major winter foraging areas in the Klamath Basin during most years. During dry and critical dry years there may be a reduction in the amount of water available to Lower Klamath Lake NWR and potentially adversely affect wintering bald eagles. Recent wetland restoration efforts (about 15,000 acres) around UKL and pilot wetlands at Tule Lake may provide expanded habitat for wintering waterfowl and foraging bald eagles. Throughout the Klamath Basin and most of Oregon , bald eagles meet or exceed recovery plan objectives. The process for de-listing bald eagles will be completed this year.

7.0 EFFECTS OF KLAMATH PROJECT ON ENDANGERED LOST RIVER AND SHORTNOSE SUCKERS

7.1 Upper Klamath Lake

The watershed above Upper Klamath Lake is outside the Klamath Project Service area. However, present and past land use practices including forestry, agriculture, residential development, and road construction have had significant negative affects on sucker spawning and rearing habitat in the tributaries and directly and indirectly affect UKL through changes in timing, duration, magnitude and quality of water entering the lake. Chiloquin Dam on the Sprague River has restricted sucker access to over 80 miles of historic spawning habitat. Also large areas of wetlands adjacent to UKL were converted to agricultural lands. Some of these agricultural lands are being restored back to wetlands.

Since 1921 when Link River Dam was constructed, water levels and releases on UKL have been carefully managed by Reclamation to meet its obligations. Water levels that generally fluctuated between 4140 and 4143 before the dam have fluctuated up to 6 feet during some years. Flow patterns in the Link River and Klamath River have been affected by irrigation deliveries into the A-Canal and Lost River Diversion Canal and PacifiCorp's hydroelectric operations. Link River Dam although fitted with a fish ladder has restricted fish passage into UKL.

The effects of on-going Project operations during above average, below average, dry and critical dry water years on surface elevation of UKL and associated effects on water quality and sucker habitat are described below.

7.1.1 Above Average Year

Historically, there were many shoreline springs that were important spawning areas for Lost River and shortnose suckers. Barkley Springs, Odessa Springs, Harriman Springs and several others along the east side of UKL are currently not being used. Sucker spawning at the few currently known areas including Sucker Springs, Silver Building Springs, Ouxy Springs, and Cinder Flat (a non-spring area) is very important. Shoreline sucker spawning occurs during late winter and spring.

UKL elevations during April range from 4142.26 to 4143.21 for above average water years (average 4142.86). At the lowest and highest elevation 65-91% and 92-100% respectively of the shoreline spawning habitats at Sucker Springs, Silver Building Springs, Ouxy Springs, and Cinder Flat are inundated to a depth of 1-foot or greater (average 80-100%). Larval suckers produced from shoreline spawning areas may be present as early as March. At the lowest April elevation of 4142.26 45-68% of the emergent vegetation areas in UKL are inundated and 100% at the highest elevation of 4143.29. On average, 75-88% of the emergent vegetation habitat is inundated. Emergent vegetation habitat inundated to a minimum depth of 1-foot (generally considered a minimum preferred depth for sucker larvae) range from 7-35% at 4142.26 to 45-67% at 4143.21 (average 30-60%).

In May elevations range from 4142.85 to 4143.29 (average 4143.03). At the lowest elevation 80-100% of the shoreline spawning habitats at Sucker Springs, Silver Building Springs, Ouxy Springs and Cinder Flat are inundated and 100% at the highest elevation (average 84-100%). Emergent vegetation habitat in UKL ranges from 75-85% at 4142.85 and 100% at 4143.29 (average 85-90%). Emergent vegetation habitat 1-foot deep and greater in UKL ranges from 27-57% at the lowest elevation to 50-70% at the highest elevation (average 32-63%).

Elevations less than full pool (4143.3) during the spring directly affect the extent and quality of rearing habitat for larval and juvenile suckers. Larval fish produced at lake shoreline and tributary stream spawning areas may be present from March through July (Simon et al. 1996, Simon et al. 2000a). This life stage appears to be dependent on shallow shoreline areas particularly those vegetated with emergent vegetation including Scirpus, Polygonum, and Sparganium (Cooperman and Markle 2000; Klamath Tribes 1996). This vegetation provides hiding cover from predation by fathead minnows and other fish, protection from high velocities and turbulence caused by wind and wave action, and complex structure for food items including zooplankton, macroinvertebrates, and periphyton (Klamath Tribes 1996). Emergent vegetation habitat has been greatly reduced over the last 90 years with the reclaiming of large tracts of marshes by private interests around the perimeter of Upper Klamath Lake by dredging and diking (approximately 40,000 acres reclaimed; Gearheart et al. 1995). Substantial acreages of former wetlands are being restored to wetlands (i.e., Tulana Farms, Wood River Ranch, Agency Lake Ranch). However, mostly due to land subsidence these properties have not been connected to the lake and therefore do not provide habitat for UKL fish. Complex shoreline habitat in the lower Williamson and Wood Rivers has been greatly reduced as a result of straightening and channelizing these areas. The lower Wood River has recently been reconnected to its historic channel and rerouting of the delta reach was done this year. Emergent vegetation habitat located in the lower Williamson River and along the eastern shoreline is now confined to narrow strips perched at relatively high elevations (Dunsmoor et al. 2000).

Channelization and diking of the lower Williamson and Wood Rivers by private interests has shortened and widened both rivers. Habitat complexity related to a highly sinuous river channel has been lost. Extensive willow, and cottonwood riparian areas were also eliminated. Floodplain habitat is mostly eliminated, and floodplain functions, such as nutrient removal, invertebrate production, and water storage, are minimal in the lower river sections. High springtime elevations during May and June back water up in the lower Williamson and Wood rivers resulting in slower velocities (PWA 1999). The channel geometry is much to wide as well as the cross-sectional area. Slower velocities may delay emigration of larval suckers to UKL. Further, sucker larvae collected in the lower Williamson River frequently had empty guts and it was surmised that many die of starvation before reaching the more productive shoreline habitats in UKL (Klamath Tribes 1996; Cooperman and Markle 2000).

Although the amount of emergent vegetation habitat in the Williamson River is relatively small, it may play a critical role in larval survival. The emergent vegetation habitats may provide food resources for emigrating larvae that need to eat since their yolk is generally depleted. Most sucker larvae use these habitats for a short period of time as they emigrate to the lake. In May at elevation 4142.85 80% is inundated and at 4143.29 100% of the emergent vegetation habitat in the lower Williamson River is inundated providing food, shelter and protection from predators (85% average). Emergent vegetation habitat 1-foot deep and greater represents 18-27% at the lowest May elevation and 43-53% at the highest elevation (25-35% average).

In April 97-100% of the full lake offshore habitat, 3 feet deep and greater (minimum depth generally used by adult suckers) is available for juvenile and adult suckers. In May 98-100% is available.

High April and May lake elevations are related to later initiation of *Aphanizomenon* blooms and lower bloom magnitude (Kann 1998). Several potential mechanisms have been identified to explain water quality benefits of high lake levels in the spring. By maintaining higher lake levels in April and May less light reaches the bottom where resting stage algae (akinetes) germinate to start the bloom cycle possibly delaying the bloom (Barbiero and Kann 1994). Also, higher lake levels/volume can reduce the rate of lake warming that leads to algae bloom initiation (Jacob Kann, Aquatic Ecosystem Sciences, per. com.). Blooms have started as early as mid-May and as late as early July (Wood et al. 1996; Kann 1998). The greater the depth during the growing season the less frequent contact of algae cells with light potentially decreasing the magnitude of the bloom events (Kann 1998). In addition, water inflows from tributaries and other sources can have higher concentrations of bloom stimulating nutrients than the lake water (Kann and Walker 1999). Since these inflows are frequently at yearly high volumes, maintaining higher lake levels would have a dilutional affect possibly resulting in a bloom of lower magnitude (Klamath Tribes 1995). Later occurring blooms decrease the probability that larval suckers will experience harmful water quality conditions caused by algal blooms. pH values during this time period have approached or exceeded lethal levels for larval and early juvenile Lost River and shortnose suckers determined in laboratory bioassays (Saiki et al. 1999).

Lost River and shortnose sucker year-classes were established (as indicated by age 0 catch rates during late summer and fall) in 5 of 6 above average water years from 1995-2000. In 1997, a poor recruitment year, larval sucker densities were high but beach seine and cast net catches of juvenile suckers were low suggesting high early juvenile mortality. Water quality conditions particularly un-ionized ammonia were very poor during summer 1997. In 1998, OSUs age 0 monitoring data generally suggested poor recruitment except for one cast net sample that captured over one thousand suckers (Simon et al. 2000a). However, juvenile entrainment data at the A-Canal and Link River Dam suggested that substantial numbers of age 0 suckers were produced that year (Gutermuth et al. 2000a).

In June, elevations range from 4142.17 to 4143.25 (average 4142.78) in above average years inundating 35-45% of the emergent vegetation habitat at 4142.17 and 98% at 4143.25 in the lower Williamson River for emigrating larval suckers (70-75% average). Emergent vegetation habitat 1-foot deep and greater range from 5-10% at the lowest elevation to 30-40% at the highest elevation (average 20-27%). Larval suckers emigrating to the lake need to feed since most have depleted their energy reserves (yolk) and emergent habitats can potentially provide a greater quantity and diversity of prey items. At the lower lake levels, larval suckers emigrating to UKL may be negatively affected by the lack of available emergent vegetation habitats. Emergent vegetation habitats in UKL, important for larvae and early juvenile sucker rearing, range from 45-68% at the lowest elevation to 93-96% at the highest elevation (75-85%). Percentages of emergent vegetation habitat 1-foot deep and greater range from 10-40% at elevation 4142.17 to 45-70% at 4143.25 (average 25-58%). Juvenile and adult offshore habitat ranges from 98-100% in June. Offshore habitat in the northern portion of UKL is 43%.

Juvenile and adult sucker offshore habitat 3 feet deep and greater is extensive ranging from 94-98% (97% average). As water quality conditions degrade in June and July, adult suckers become more restricted in their distribution. Most utilize the northern portion of UKL. This area represents 43% of Upper Klamath and Agency Lakes full lake surface area.

From July through September, blue-green algae blooms are a dominant factor affecting Upper Klamath Lake water quality. Maintaining high lake levels may increase the probability of smaller-sized algae blooms and associated pH and dissolved oxygen levels that are generally lower with less daily fluctuation than would occur during large blooms. Increased lake level lowers light availability to algae, which lowers growth rate and therefore limits the actual size of the algae bloom. Most photosynthesis is limited to the top meter of the water column during a bloom (Kann 1998). During a mixed situation (which frequently occurs), algae spend a proportion of time at deeper depths where respiration exceeds photosynthesis, greatly retarding growth. The deeper the water column the greater the dilution effect on algal biomass. Increased lake level dilutes total phosphorus (an important plant nutrient) entering the water column from the sediments, which in turn limits the maximum possible size of the algae blooms (Klamath Tribes 1995). These two direct effects of lake level are then enhance further by the positive feedback cycle. In this cycle, algal growth increased pH and thereby stimulates the release of TP from the sediments, creating the potential for algae to reach even higher biomass. Increased lake level inhibits this cycle through each of the two direct pathways.

At the highest June elevation (4143.25) there is a higher probability of lower bloom magnitude due to algae and nutrient dilution than at the lowest June elevation (4142.17). With lower algae growth, pH levels are usually lower and supersaturated dissolved oxygen levels less frequent. Dissolved oxygen concentrations are likely to have lower daily fluctuations. Fish survival particularly the more vulnerable early life stages, is likely to be higher as well.

In July UKL elevations range from 4140.83 to 4142.73 (average 4141.93). Emergent vegetation habitat in UKL ranges from 1-27% at the lowest elevation to 70-80% at the highest elevation in July (average 33-60%). Emergent vegetation habitat 1-foot deep and greater ranges from 0-5% at 4140.83 to 20-55% at 4142.73 (5-25% average). By July most sucker larvae are well developed and many have transformed to juveniles and may be less dependent on emergent vegetation habitats.

In August and September, UKL elevations range from 4138.95 to 4142.34 (average 4141.07 August, 4140.63 September). Inundation of emergent vegetation habitats in UKL ranges from 0% at the lowest elevation to 50-70% at the highest elevation. In August the average emergent vegetation habitat range from 5-35% and 0-20% in September. Emergent vegetation habitat 1-foot deep and greater ranges from 0% at 4138.95 to 15-40% at 4142.34 (average 0-10% August, 0-5% September). Age 0 juvenile suckers appear to be less dependent on emergent vegetation during late summer, occupying un-vegetated shoreline areas and offshore areas.

Juvenile and adult sucker offshore habitat range from 66% at 4138.95 to 98% at 4142.34 with averages for August of 94% and September at 86%. Most adult suckers are likely confined to the northern portion of UKL during these months. Only 29% and 43% of the full pool UKL habitat are available at elevation 4138.95 and 4142.34 respectively (average 42% August, 40% September). The smaller habitat area at lower elevations may lead to greater competition for food and space, slower growth rates, predation, and greater risk of disease transmission than at the higher elevations.

Blue-green algae blooms and die-offs continue to be a dominant factor affecting UKL water quality during August and September. During algae die-offs low dissolved oxygen and high un-ionized ammonia concentrations can occur resulting in stressful and/or lethal conditions for fish. Mixing occurs concurrently with the algal crash and it is the algal crash that is largely responsible for water column wide low DO. Prior to the bloom crash stable water column conditions enhance low off-bottom DOs through diminished re-aeration, and lower photosynthetic oxygen production (light limitation due to algal shading). When the bloom crashes, water column BOD increases and at the same time photosynthetic oxygen production is reduced throughout the water column. At lower elevations, the ratio of lake volume to sediment surface area decreases. As this ratio decreases, the depletion rate of dissolved oxygen in the water column increases because the lower water volume holds less oxygen relative to the biochemical oxygen demand of the sediments. It has also been shown that increased resuspension of sediments that is higher at lower lake levels causes more depletion of oxygen and release of ammonia into the water column (Barica 1974). Additionally, during calm meteorological conditions there is an increased risk of poor water quality at lower lake levels. During calm periods, anoxic (no oxygen) conditions occur at the lake bottom leading to greater production of ammonia that is subsequently mixed in the water column when winds occur. Low dissolved oxygen conditions also occur near the bottom under calm conditions due to high biochemical oxygen demand. When mixing occurs the low dissolved oxygen is spread throughout the water column. Large algae blooms and subsequent crashes have occurred during late summer in 1995, 1996, and 1997 (Perkins et al. 2000b).

Recent information suggests that freshwater inflow areas thought to be sucker refuges when water quality degrades in Upper Klamath Lake are used less frequently than previously suspected (Reclamation 1996a). Radio-tagged adult suckers generally concentrated in close proximity to but not in freshwater inflow areas before and during periods of poor water quality and sucker die-offs at depths of 3 feet and greater particularly near Pelican Bay (Peck 2000). Other freshwater inflow areas that likely provide refuge habitat for suckers during fish die-offs and periods of poor water quality include: Williamson River, Sevenmile Canal, Odessa Creek, Short Creek, Sucker Springs, Barkley Springs and other spring areas around the lake.

Water quality in these transition areas are generally better than that found elsewhere in the lake but more variable because of the influence of lake water quality, proximity to bottom sediment and wind caused mixing and re-suspension of bottom sediment. Degraded water quality has been monitored at times in these areas when depths were shallow (Reclamation 1996a; Klamath Tribes, unpublished data).

Bottom elevations adjacent to the Williamson River, Wood River, Pelican Bay, Odessa Creek, Short Creek are about 4136. Water depths in refuge habitats adjacent to these freshwater inflow areas range from 3.66 to 6.34 feet in August (average 5.07 feet) and 2.95 to 5.98 feet in September (average 4.63 feet).

Approximately 17,000 acres of wetlands remain around UKL not including the 15,000 acres currently being restored (Gearheart et al. 1995). Most marshes extend from the full pool elevation (4143.3) out to elevation 4136-4141 depending on the vegetation type, slope, aspect and substrate conditions (PWA 1999, Dunsmoor et al. 2000). Most of the emergent marshes are dominated by hardstem bulrush that generally extends out to an elevation of 4138-4140 feet. During above average years at least some of the larger wetlands including Hanks Marsh and Upper Klamath marsh are partially inundated during the fall. Water quality conditions are generally better adjacent to and in these areas (Forbes et al. 1998). The humic substances present in the marsh waters appear to inhibit *Aphanizomenon* growth. With low phytoplankton densities water quality is generally better in the marsh edge areas than open water areas (except when wind and currents carry large concentrations of algae to these areas). Uncovering of submerged wetlands and shoreline sediments may increase the aerobic decomposition of these soils that occurs when they are exposed to air or oxygenated water. This could result in the release of nitrogen and phosphorus into the lake when water levels re-flood these areas. However, UKL elevations during above average years are high enough to keep almost all wetland soils are saturated.

October and November UKL elevations range from 4138.98 to 4141.41 (average 4140.57 October, 4140.53 November). Emergent vegetation habitats are out of the water at the lowest elevation and 15-45% inundated at the highest elevation (average 0-20%). Most age 0 suckers occupy un-vegetated shoreline and offshore areas during late summer and fall, so inundation of the shoreline emergent vegetation areas may be less important.

Juvenile and adult offshore habitat ranges from 66-96% with an average value of about 89% for October and November. Although there is a general pattern of dispersal by adult suckers in UKL, most fish remain in the northern half of the lake. Only 29% of the full pool offshore habitat is available at the lowest elevation and 42% at the highest elevation (average 40%October, 40% November).

Water quality conditions improve during the fall with declining temperatures. However, blue-green algae blooms and die-offs have been documented during October and November in some years. At the lowest October and November UKL elevations there is a higher level of risk of poor water quality (i.e., low dissolved oxygen, high pH, high un-ionized ammonia) than at the higher UKL elevations.

During December and January UKL elevations range from 4139.58 to 4142.40 (average 4140.64 December, 4141.05 January). Algae growth is relatively low compared to the other seasons, most fish and other organisms are relatively inactive due to cold-water temperatures, and water quality conditions are generally good. However, harmful and/or lethal low dissolved oxygen levels can occur during ice-cover conditions. Ice-cover conditions frequently occur from December through February lasting from a few weeks to several months. The depletion rate of dissolved oxygen in the water column increases as the depth/volume of the lake decreases because the lower volume holds less oxygen relative to the biological oxygen demand of the sediments. Ice-cover also eliminates wind-induced mixing that adds oxygen to water and prevents stratification. With ice-cover conditions stratification occurs and near bottom water may become anoxic (no oxygen) leading to release of high levels of ammonia from the sediments into the water column. When the ice-cover breaks up, the high ammonia mixes throughout the water column potentially having a negative affect on sucker growth and survival. There would be an increased risk of poor water quality at lower elevations compared to the higher elevations.

In February and March, Lost River and shortnose suckers begin spawning activities at shoreline locations in UKL. The lower extent of spawning habitat at Sucker Springs, Cinder Flat, Silver Building Spring, and Ouxy Spring along the east side of UKL are 4138.5, 4138, 4139, and 4140.5 respectively. Most spawning during February and early March occurs at Sucker Springs while spawning at the other sites occurs from mid-late March to May. February and March elevations range from 4140.56 to 4142.73 (average 4141.86 February, 4142.43 March). Inundation of Sucker Springs to a depth of at least 1-foot ranges from about 43% at the lowest elevation to 95% at the highest. On average, 73% of the spawning area is inundated in February and 90% in March. Sucker spawning may be negatively affected by the reduced habitat at the lower elevations. Lake levels continue to increase throughout the spring months during this water year type providing more shoreline habitat for spawning.

Water quality conditions are generally good during this time of year. However, ice-cover conditions frequently occur during February and early March resulting in a potential risk of low dissolved oxygen and high un-ionized ammonia. There would be a higher probability of poor water quality at the lower February and March elevations than the higher elevations.

7.1.2 Below Average Years

UKL elevations during April in below average years range from 4142.15 to 4143.06 (average 4142.68). At the lowest elevation 63-88% of the shoreline spawning habitats are inundated to a depth of at least 1 foot (average 78-100%). Emergent vegetation habitat in UKL ranges from 35-65% at the lowest elevation to 90-95% at the highest elevation (average 70-80%). Emergent vegetation habitat 1-foot deep and greater ranges from 5-35% at 4142.15 to 35-65% at 4143.06 (average 20-55%). Juvenile and offshore habitat ranges from 97-99%.

In May elevations range from 4142.22 to 4143.16 (average 4142.64). Shoreline spawning habitat ranges from 67-90% at 4142.22 to 90-100% at 4143.16 (average 77-100%). Inundation of emergent vegetation habitat in the lower Williamson River ranges from 35-47% at the lowest elevation to 95% at the highest elevation providing shelter and feeding areas for emigrating larval suckers (60-65% average). However, only 5-10% of the emergent vegetation habitat is 1-foot deep and greater at the lowest elevation and 35-50% at the highest May elevation (10-20% average). Emergent vegetation habitat in UKL ranges from 45-68% at 4142.22 to 90-95% at 4143.16 (average 65-80%). UKL emergent vegetation habitat 1 foot deep and greater ranges from 7-35% at the lowest elevation to 43-68% at the highest elevation (average 20-50%). There may be better survival and growth of larval suckers at the higher elevations because they would have more emergent habitat available providing protection from turbulence caused by wind and wave action, protection from predators, less competition with other fish and potentially a greater quantity and diversity of food resources. Offshore areas 3 feet deep and greater, habitat for juvenile and adult suckers, ranges from 98% at 4142.15 to 99.5% at 4143.06.

The high April and May elevations for this water year type may have increased the probability of a later occurring and smaller-sized *Aphanizomenon* bloom in spring and early summer. This condition would decrease the probability that larval suckers would experience harmful water quality conditions caused by the algae blooms. With good water quality larval suckers (and other life stages) would benefit with higher survival and faster growth than if water quality conditions were poor.

In June UKL elevations range from 4141.30 to 4142.79 (average 4142.05). Inundation of emergent vegetation habitats in the lower Williamson River ranges from 5-15% at the lowest June elevation to 73-80% at the highest June elevation (average 27-40%). Emergent vegetation habitat 1-foot deep and greater range from 0% at the lowest June elevation to 18-28% at the highest June elevation (average 0-5%). Larval suckers emigrating may have very little habitat at the lowest elevation for shelter and feeding sites while much of the habitat would be available at the highest elevation. Emergent vegetation habitats in UKL are partially inundated in June, 10-40% at the lowest elevation and 75-85% at the highest elevation (35-60% average). Emergent vegetation habitat 1 foot deep and greater range from 0-15% at 4141.30 to 25-57% at 4142.79 (average 5-35%).

In July UKL elevations range from 4140.00 to 4141.91 (average 4140.97). Emergent vegetation habitat in UKL ranges from 0-8% at elevation 4140.00 to 30-60% at 4141.91 (average 5-35%). Emergent vegetation habitat 1-foot deep and greater ranges from 0% at 4140.00 to 5-30% at 4141.91 (average 0-10%). There may be a greater negative affect on larval sucker growth and survival at the lower elevations because of the lack of habitat during July. Juvenile and adult offshore habitat ranges from 96-98% in June (97% average) to 84-97% in July (94.5% average). Most adult suckers are probably restricted to the northern portion of UKL during the summer. Forty-two to forty-three percent of the offshore habitat is inundated in the northern portion of UKL during June (average 43%) and 38-43% in July (average 42%).

Water quality conditions in June and July are substantially affected by blue-green algae blooms. At the higher June and July elevations there is a higher probability of lower bloom magnitude due to algae and nutrient dilution.

Smaller-sized blooms are associated with better water quality conditions (i.e., lower pH, less variable dissolved oxygen) that may lead to higher fish survival and growth.

August and September elevations range from 4138.85 to 4141.80 (average 4140.07 August, 4139.53 September). Emergent vegetation habitats in UKL range from 0% at 4138.95 to 25-57% at 4141.80. On average, only 0-10% and 0-5% of the emergent habitats are inundated in August and September respectively. Emergent vegetation habitat 1-foot deep and greater range from 0% at 4138.85 to 2-28% at 4141.80 (average 0% August and September). However, because age 0 juveniles occupy a wide range of habitats including un-vegetated shoreline areas and offshore areas during these months they may not be greatly impacted by the lack of available emergent vegetation habitat.

Juvenile and adult sucker offshore habitat range from 64% at the lowest elevation to 97% at the highest elevation. At the average August elevation of 4140.07, 84% of the adult habitat is available and about 74% at the average September elevation of 4139.53. Because most adult suckers are probably restricted to the northern portion of UKL during these months, only 23% of the full lake habitat is available at 4138.85 and 42% at elevation 4141.80 (average 39% August, 34% September). This reduced habitat may negatively affect sucker survival and growth.

Water depths in refuge habitat adjacent to Pelican Bay, Williamson River, Wood River, Odessa Creek and Short Creek in August range from 2.85 feet at 4138.85 to 5.8 feet at 4141.80 (average 4.07 feet). In September water depths range from 2.18 feet at 4138.18 to 5.46 feet at 4141.46 (average 3.53 feet). At the lowest elevation with water depths less than 3 feet deep in refuge areas, adult suckers may be forced to move to areas with potentially harmful/lethal water quality.

The higher August and September elevations may increase the probability of smaller-sized algae blooms, lower pH conditions, more stable dissolved oxygen concentrations (less daily fluctuation), and provide better conditions for fish survival and growth compared to the lower elevations. During these months, algae die-offs also occur with increased frequency that lead to low dissolved oxygen conditions and possibly high ammonia concentrations. The higher elevations may reduce the probability of harmful and/or lethal water quality conditions because of dilution, lower re-suspension of sediments, and higher water volume to sediment surface area.

October and November elevations range from 4138.36 to 4141.35 (average 4139.51 October, 4140.00 November). All emergent vegetation habitats are out of the water at the lowest elevation and 15-45% inundated at the highest elevation (average 0-2% October, 0-7% November). None of the emergent vegetation habitat is inundated to depths of 1-foot and greater. However, because age 0 suckers generally occupy un-vegetated shoreline areas and offshore areas in these months the lack of emergent vegetation habitat may not be critical for their survival and growth.

Juvenile and adult sucker offshore habitat range from about 55% at elevation 4138.36 to 96% at elevation 4141.35. On average, 75% of the habitat is available in October and 84% in November. At 4138.36, 26% of the offshore habitat in the northern portion of UKL is available and 42% at 4141.35 (average 34% October, 39% November).

Water quality conditions are generally good during the fall. However, stressful and/or lethal levels of low dissolved oxygen, and high un-ionized ammonia and pH can still occur. At the lower October and November UKL elevations there is a higher risk of poor water quality than at the high UKL elevations.

In December and January, elevations range from 4138.80 to 4143.50 (average 4140.60 December, 4140.96 January). The major concern during these months is poor water quality conditions associated with ice-cover. Harmful and/or lethal dissolved oxygen and un-ionized ammonia conditions may occur under these circumstances. There was an increased risk of poor water quality at the lower elevations compared to the higher elevations. Another concern is the probability of refilling the lake for the next season.

In February and March, elevations range from 4140.15 to 4142.73 (average 4141.41 February, 4142.25 March). Inundation of Sucker Springs, the shoreline spawning location where most spawning occurs during these months, is about 35% at the lowest elevation and 95% at the highest. On average, 61% of the spawning habitat is inundated in February and 85% in March to a depth of 1-foot or greater. Sucker spawning success may be less at the lower elevations because a smaller area of spawning habitat is inundated.

Ice-cover conditions can occur during these months resulting in a potential risk of low dissolved oxygen and high un-ionized ammonia. There is a higher probability of poor water quality at the lower February and March elevations than the higher elevations. Ice-cover conditions after early March are rare therefore water quality is likely to be good at this time.

7.1.3 Dry Years

UKL elevations in April range from 4141.68 to 4142.95 (average 4142.44). At the lowest elevation 50-82% of the shoreline spawning habitats is inundated to a depth of at least 1-foot and 84-100% at the highest elevation (average 75-100%). Emergent vegetation habitats in UKL are inundated 20-55% at the lowest elevation and 80-90% at the highest elevation in April. On average, 55-75% of the emergent vegetation habitat is inundated in April. Emergent vegetation habitat 1-foot deep and greater ranges from 1-25% at the lowest elevation to 85-90% at the highest elevation (average 15-45%). Offshore habitat for juvenile and adult suckers ranges from 96-99%.

In May UKL elevations range from 4141.40 to 4142.85 (average 4142.43). Shoreline spawning habitat ranges from 45-78% at 4141.40 to 80-100% at 4142.85 (average 72-100%). At the lowest May elevation of 4141.40 15-45% of the emergent vegetation habitat is available and 80-90% at the highest May elevation (average 55-75%). Emergent vegetation habitat 1-foot deep and greater ranges from 0-18% at 4141.40 to 27-57% at 4142.85 (average 13-45%). Emergent vegetation habitat in the lower Williamson River in May during the larval sucker emigration period range from 5-15% at the lowest elevation and 75-80% at the highest elevation (average 47-57%). Habitat 1-foot deep and greater ranges from 0% at 4141.40 to 27-53% at 4142.85 (average 8-18%). Sucker larvae may have lower survival and growth at the lower April and May elevations because of the lack of emergent vegetation habitat flooded. With no structure to hide in, sucker larvae are vulnerable to predation and may be exposed to turbulence caused by wind and wave action. There may also be a lower quantity and diversity of zooplankton and other invertebrate prey in unvegetated shoreline areas. Also, there is a concern about the negative effects of competitive interactions arising from concentrating large numbers of sucker and cyprinid larvae into progressively smaller habitat volumes. Because there is so little emergent vegetation habitat remaining in the lower Williamson River any reduction may negatively affect larval sucker survival.

Offshore habitat used by juvenile and adult suckers range from 96-99% in May. At the highest May elevation of 4142.85 there is a higher probability of a later occurring and smaller-sized *Aphanizomenon* bloom in spring and early summer than at the lowest elevation of 4141.40. The higher elevations decrease the probability that larval suckers may experience harmful and/or lethal water quality caused by algae blooms. The higher elevations may have better water quality due to algae and nutrient dilution.

During June UKL elevations range from 4140.39 to 4142.45 (average 4141.63). Emergent vegetation habitat in the lower Williamson River is out of the water at the lowest elevation and inundated 50-60% at the highest elevation (average 10-20%). Emergent habitat 1-foot deep and greater in the Williamson Rive range from 0% at 4140.39 to 8-18% at 4142.45 (1% average). Since much of the larval emigration in the Williamson River occurs during this month, larvae do not have much emergent vegetation habitat to use for feeding and predator avoidance in most dry years. Emergent vegetation habitat in UKL ranges from 0-18% at 4140.39 and 55-75% at 4142.45 (average 20-50%). Habitat 1-foot deep and greater ranges from 0% at the lowest elevation to 15-45% (average 0-22%). Even if sucker larvae reached the lake little emergent vegetation habitat is available potentially resulting in lower growth and survival. Juvenile and adult offshore habitat range from 88-99% in June (average 96%). Forty to forty-two percent of the full lake habitat in the northern half of UKL is available (average 41%).

July elevations range from 4139.10 to 4140.86 (average 4140.21). None of the vegetation is inundated at the lowest elevation and 2-28% at the highest elevation (average 0-12%). Emergent habitat 1-foot deep and greater range from 0% at the lowest elevation to 0-5% at the highest elevation. During most dry years, very little emergent vegetation habitat is available for larval and early juvenile suckers forcing them to occupy un-vegetated habitats where they were more vulnerable to predation, physical damage due to wind and wave action and potentially had a lower diversity of zooplankton and other invertebrate prey.

Juvenile and adult offshore habitat ranges from 66-92% in July (average 86%). In the northern portion of UKL, 29-42% of the offshore habitat 3 feet deep and greater is available (average 40%).

Water quality conditions during June and July are affected by blue-green algae blooms that usually occur. The higher elevation years may have a higher probability of lower bloom magnitude due to algae and nutrient dilution. Smaller-sized blooms are associated with better water quality conditions particularly lower pH and less fluctuation of dissolved oxygen that may lead to higher fish survival and growth.

August and September elevations range from 4137.55 to 4139.78 (average 4139.11 August, 4138.49 September). Emergent vegetation habitats are out of the water. Age 0 suckers are restricted to un-vegetated shoreline areas and offshore habitat. Since these fish appear to utilize a wider range of habitats this loss may not have a negative affect on survival and growth.

Juvenile and adult habitat ranges from 44% at 4137.55 to 80% at 4139.78. On average 68% and 58% of the offshore habitat is available in August and September respectively. Offshore habitat in the northern portion of UKL ranges from 20% at the lowest elevation to 37% at the highest elevation (average 30% August, 26% September).

Blue-green algae bloom die-offs occur with increased frequency during August and September leading to low dissolved oxygen and high un-ionized ammonia conditions. The higher elevations during this period would have a reduced risk of achieving harmfully low dissolved oxygen and high un-ionized ammonia conditions because of dilution, lower resuspension of sediments, and higher water volume to sediment surface area. However, even the highest elevations for this year type may not provide enough protection for water quality.

Refuge habitat adjacent to freshwater inflow areas range from 1.55 feet deep at 4137.55 to 3.78 feet deep at 4139.78 (average 3.11 August, 2.49 September). Water depths are adequate in the refuge habitats at the highest elevation but not at the lowest. Adult suckers are likely forced to move into areas with potentially harmful/lethal water quality.

October and November elevations range from 4138.18 to 4140.5 (average 4138.66 October, 4139.78 November). Emergent vegetation habitats are out of the water. However, most age 0 suckers occupy un-vegetated shoreline habitat and offshore areas during these months. Juvenile and adult habitat range from 54% at 4138.18 to 89% at 4140.5 with an average of 60% and 80% available for October and November respectively. Offshore habitat in the northern portion of UKL ranges from 24% at 4138.18 to 40% at 4140.5 (average 27% October, 36% November). Because water quality is generally improving during these months, fish may occupy more of the available habitat rather than be restricted to the northern portion of UKL.

Stressful water quality conditions including high pH, low dissolved oxygen, and high un-ionized ammonia can persist during these months affecting sucker growth and survival. At the lower October and November UKL elevations there is a higher risk of poor water quality than at the higher elevations.

In December and January, elevations range from 4139.66 to 4141.81 (average 4140.7 December, 4141.12 January). Water quality conditions are normally good during these months. However, during ice-cover conditions harmfully low dissolved oxygen and high un-ionized ammonia concentrations can occur. There was an increased risk of poor water quality during lower elevation years compared to the higher elevation years.

In February and March, elevations range from 4140.41 to 4142.84 (average 4141.62 February, 4142.42 March). Lost River suckers begin spawning at Sucker Springs during these months. There is 40% of the spawning habitat inundated at the lowest elevation and 95% at the highest elevation. On average 65% and 90% is inundated in February and March respectively.

Ice-cover conditions can occur during these months resulting in a potential risk of harmfully low dissolved oxygen and high un-ionized ammonia concentrations. There is a higher probability of poor water quality at the lower February and March elevations than the higher elevations. The threat of ice-cover is usually over by early March.

7.1.4 Critical Dry Years

UKL elevations in April range from 4141.68 to 4142.12 (average 4141.90). Shoreline spawning habitat ranges from 53-83%. On average, 60-86% are inundated in April. Shoreline sucker spawning success may be negatively affected at these elevations. Emergent vegetation habitat in UKL ranges from 20-55% at the lowest elevation and 35-65% at the highest elevation (average 30-60%). Emergent vegetation habitat 1-foot deep and greater ranges from

1-25% at 4141.68 and 7-37% at 4142.12 (average 3-30%).

In May elevations range from 4140.70 to 4142.00 (average 4141.35). Shoreline spawning habitat ranges from 17-67% at elevation 4140.70 to 61-87% at 4142.00 (average 38-78%). Emergent vegetation habitat in UKL ranges from 1-25% at the lowest elevation to 33-63% at the highest elevation (average 10-45%). Emergent vegetation habitat 1-foot deep and greater ranges from 1-5% at 4140.70 to 5-33% at 4142.00 (average 0-17%). Larval suckers may have lower survival and growth because of the lack of rearing habitat that provides shelter and food. In May, when larval emigration in the Williamson River is high, none of the emergent vegetation habitat is inundated at the lowest elevation. At the highest elevation 25-35% of the emergent vegetation is inundated. On average 5-10% of the emergent vegetation habitat in the lower Williamson is inundated. Only 0-5% of the emergent vegetation habitat is 1-foot deep and greater. Because so little emergent vegetation habitat is inundated during April and May larval sucker survival may be negatively affected.

Juvenile and adult offshore habitats are mostly available in April ranging from 95-98%. In May 91-97% of the offshore habitat is 3 feet deep and greater (average 95%).

Due to the relatively low lake elevations during April and May compared to other water year types, there is a higher probability of an early occurring and larger-sized *Aphanizomenon* bloom in spring and early summer. During critical dry years inflow and external nutrient loading to UKL are low compared to other water year types. However, because the magnitude of the first blue-green algae bloom is largely driven by nutrient concentrations in the water column, the low lake levels, better light environment, and greater potential for warming overshadow the low external loading resulting in conditions that support a large bloom. With a large bloom, there would be a higher probability of harmful and/or lethal water quality (i.e., high pH, high dissolved oxygen concentrations).

In June, UKL elevations range from 4139.45 to 4140.81 (average 4140.13). Emergent vegetation habitat in the lower Williamson River is dry and larval suckers may have lower survival rates because of the absence of emergent vegetation habitat that provides shelter and feeding sites. July elevations range from 4138.77 to 4139.04 (average 4138.91). Availability of emergent vegetation habitat in UKL ranges from 0-2% at the lowest elevation to 2-27% at the highest elevation in June (average 0-8%). Essentially none of the emergent vegetation habitat in UKL is 1-foot deep or greater. In July none of the emergent vegetation habitat is inundated. During both June and July larval suckers are forced to use mostly un-vegetated areas where they are more vulnerable to predation, physical damage due to turbulence caused by wind and wave action, competition with other fish and have a lower diversity of zooplankton and other invertebrate prey.

Juvenile and adult offshore habitat in June ranges from 75-92% (average 84%). Habitat in the northern portion of UKL, where most adult suckers are found during the summer, ranges from 34-41% (average 39%). In July 63-66% of the offshore habitat is available (average 65%). Only 25-29% of the full lake habitat is available in the northern portion of UKL (average 28%).

Water quality conditions in June and July are frequently poor with high pH, high ammonia and supersaturated dissolved oxygen concentrations associated with blue-green algae blooms. At the low critical dry year elevations there is a higher probability of large *Aphanizomenon* blooms due to concentration of algae and nutrients compared to elevations in other water year types. The higher elevations may reduce the probability of poor water quality compared to the lower elevations because of light and dilution effects on reduction of algal biomass.

August and September elevations range from 4136.84 to 3137.72 (average 4137.62 August, 4137.14 September). Emergent vegetation habitats and un-vegetated shoreline areas with coarse substrates are mostly out of the water. However, because age 0 suckers occupy a wide range of habitats including offshore areas they may not be seriously impacted. Other shoreline dependent species like fathead minnows may be forced to occupy less suitable habitats negatively affecting their survival and growth.

Juvenile and adult sucker offshore habitat range from 35-46% for all of UKL (average 45% August, 38% September) and 16-22% for the northern portion of UKL (average 21% August, 19% September). This reduced habitat may lead to fish crowding which along with poor water quality can result in stress, slower growth and disease. Fish die-offs associated with poor water quality and disease generally occur during these months. Refuge habitat adjacent to freshwater inflow areas range from 0.84 feet deep at 4136.84 to 1.72 feet deep at 4137.72

(average 1.62 feet August, 1.14 feet September). Adult suckers are relegated to lake areas with potentially harmful/lethal water quality.

In August and September, algae die-offs occur with increased frequency leading to low dissolved oxygen and high un-ionized ammonia concentrations. Mixing occurs concurrently with the algal crash and it is the algal crash that is largely responsible for water column wide low DO. Prior to the bloom crash stable water column conditions enhance low off-bottom DOs through re-aeration, and lower photosynthetic oxygen production (light limitation due to algal shading). When the bloom crashes, water column BOD increases and at the same time photosynthetic oxygen production is reduced throughout the water column. Because there is a low lake volume to sediment area ratio, the depletion rate of dissolved oxygen in the water column increases because the lower water volume holds less oxygen relative to the biological oxygen demand of the sediments. Re-suspension of sediments is also increased at low lake levels causing more depletion of oxygen and release of un-ionized ammonia into the water column. Additionally, during calm meteorological conditions there is an increased risk of poor water quality at these low lake levels. During calm periods, anoxic conditions occur at the lake bottom leading to greater production of ammonia that is subsequently mixed in the water column when winds occur. Low dissolved oxygen conditions also occur near the bottom under calm conditions due to high biological oxygen demand. When mixing occurs the low dissolved oxygen is spread throughout the water column. There is a much higher probability of harmful and/or lethal water quality conditions with the low elevations in this year type compared to the other year types with higher elevations.

October and November elevations range from 4136.93 to 4138.32 (average 4137.26 October, 4138.06 November). Emergent habitats are out of the water. However, age 0 juveniles generally move offshore in later summer and fall. Juvenile and adult sucker deep-water habitat range from 37-52% in UKL (average 41% October, 50% November) to 18-25% in the northern portion of UKL where most suckers were found during the summer (average 19% October, 23% November). The relatively small amount of habitat available may negatively affected sucker survival and growth.

Water quality conditions are generally good during the fall due in part to the cooler water temperatures. However, algae blooms and die-offs can continue during these months resulting in potentially harmful and/or lethal water quality conditions. There was a higher probability of poor water quality during critical dry years than other year types with higher October and November elevations.

In December and January, UKL elevations range from 4138.58 to 4140.27 (average 4138.93 December, 4140.27 January). Harmful and/or lethal water quality can occur during ice-cover conditions. Since the depletion rate of dissolved oxygen in the water column increases as the depth/volume of the lake decreases because the lower volume holds less oxygen relative to the biological oxygen demand of the sediments. Ice-cover also eliminates wind-induced mixing that adds oxygen to water and prevents stratification. With ice-cover conditions stratification occurs and near bottom water may become anoxic leading to release of high concentrations of ammonia from the sediments into the water column. When the ice-cover breaks up, the high ammonia and low dissolved oxygen mixes throughout the water column. The low December and January elevations for critical dry years have a higher probability of poor water quality than other water year types with higher elevations. These levels may have a negative affect on sucker growth and survival.

Elevations in February and March range from 4140.94 to 4142.19 (average 4141.15 February, 4142.00 March). There is 52-83% of the spawning habitat at Sucker Springs inundated. On average, 56% of the habitat is inundated in February and 77% in March.

Ice-cover conditions can occur during these months resulting in an increased risk of harmfully low dissolved oxygen and high un-ionized ammonia concentrations as described for December and January.

7.1.5 Water Year Comparison

A comparison of effects of historic lake level operations (the proposed action) on sucker spawning, rearing habitat, and refugie habitat and water quality by water year type is presented in Table 9.

Table 9. Comparison of the effects of historic operations on sucker habitat and water quality parameters for above average, below average, dry and critical dry year types by month.

Month	Subject	Above Average Year	Below Average Year	Dry Year	Critical Dry Year
		Minimum Average	Minimum Average	Minimum Average	Minimum Average
APRIL	Shoreline spawning habitat	65-91% 80-100%	63-80% 78-100%	50-82% 75-100%	53-83% 60-86%
	UKL emergent veg. habitat	45-68% 75-88%	35-65% 70-80%	20-55% 55-75%	20-55% 30-60%
	Emergent habitat > 1 ft. deep	7-35% 30-60%	5-35% 20-55%	1-25% 15-45%	1-25% 3-30%
	Offshore adult habitat	97% 99%	97% 98%	96% 97%	95% 97%
MAY	Shoreline spawning habitat	80-100% 84-100%	67-90% 77-100%	45-78% 72-100%	17-67% 38-78%
	UKL emergent veg. habitat	75-85% 85-90%	45-68% 65-80%	15-45% 55-75%	1-25% 10-45%
	Emergent habitat > 1 ft. deep	27-57% 32-63%	7-35% 20-50%	0-18% 13-45%	1-5% 0-17%
	Williamson R. emerg. habitat	80% 85%	35-47% 60-65%	5-15% 47-57%	0% 0-5%
	Williamson R. emerg. > 1 ft.	18-27% 25-35%	5-10% 10-20%	0% 8-18%	0% 0-5%
	Offshore adult habitat	98% 99%	98% 99%	96% 98%	91% 95%
	Algae dilution/light limitation	High High	Moderate High	Low Moderate	Low Low
JUNE	UKL emergent veg. habitat	45-68% 75-85%	10-40% 35-60%	0-18% 20-50%	0-2% 0-8%
	UKL emergent > 1 ft. deep	10-40% 25-58%	0-15% 5-35%	0% 0-22%	0% 0%
	Williamson R. emerg. Habitat	35-45% 70-75%	5-15% 27-40%	0% 10-20%	0% 0%
	Williamson R. emerg. > 1 ft.	5-10% 20-27%	0% 0-5%	0% 1%	0% 0%
	Offshore adult habitat	98% 99%	96% 97%	88% 96%	75% 84%
	Offshore adult N. ½ UKL	43% 43%	43% 43%	40% 41%	34% 39%
	Algae dilution/light limitation	Moderate High	Low Moderate	Low Moderate	Low Low
JULY	UKL emergent veg. habitat	1-27% 33-60%	0-8% 5-35%	0% 0-12%	0% 0%
	UKL emergent > 1 ft. deep	0-5% 5-25%	0% 0-10%	0% 0-5%	0% 0%
	Offshore adult habitat	94% 97%	84% 95%	66% 86%	63% 65%
	Offshore adult N. ½ UKL	43% 43%	38% 42%	29% 40%	25% 28%
	Algae dilution/light limitation	Low Moderate	Low Low	Low Low	Low Low
	Sediment dilution	Moderate High	ModerateModerate	ModerateModerate	Low Low
AUGUST	UKL emergent veg. habitat	0% 5-35%	0% 0-10%	0% 0%	0% 0%
	Offshore adult habitat	72% 94%	64% 84%	57% 68%	43% 45%
	Offshore adult N. ½ UKL	36% 42%	23% 39%	25% 30%	20% 21%
	Adult refuge habitat (depth)	3.7 ft. 5.1 ft.	2.9 ft. 4.1 ft.	2.4 ft. 3.1 ft.	1.5 ft. 1.6 ft.
	Algae dilution/light limitation	Low Low	Low Low	Low Low	Low Low
	Sediment dilution	Moderate High	Low Moderate	Low Moderate	Low Low
SEPT.	UKL emergent veg. habitat	0% 0-20%	0% 0-5%	0% 0%	0% 0%
	Offshore adult habitat	66% 86%	51% 74%	43% 58%	35% 38%
	Offshore adult N. ½ UKL	29% 40%	24% 34%	21% 26%	16% 19%
	Adult refuge habitat (depth)	3.0 ft. 4.6 ft.	2.2 ft. 3.5 ft.	1.6 ft. 2.5 ft.	0.8 ft. 1.1 ft.
	Algae dilution/light limitation	Low Low	Low Low	Low Low	Low Low
	Sediment dilution	Low Moderate	Low Moderate	Low Low	Low Low
OCT.	Offshore adult habitat	66% 89%	56% 75%	52% 60%	37% 41%
	Offshore adult N. ½ UKL	29% 40%	25% 34%	23% 27%	18% 19%
	Algae dilution/light limitation	Low Low	Low Low	Low Low	Low Low
	Sediment dilution	Low Moderate	Low Moderate	Low Low	Low Low
NOV.	Offshore adult habitat	71% 89%	66% 84%	66% 80%	46% 50%
	Offshore adult N. ½ UKL	34% 40%	29% 39%	29% 36%	21% 21%
DEC.	Winter kill risk	Moderate Low	High Low	Moderate Low	High High
JAN.	Winter kill risk	Moderate Low	Moderate Low	Low Low	Low Low
FEB.	Winter kill risk	Low Low	Low Low	Low Low	Low Low
	Shoreline spawning	41% 73%	35% 61%	39% 65%	52% 56%
MARCH	Shoreline spawning	53% 90%	60% 85%	69% 90%	70% 77%

The information in Table 9 represents a summarization of the information presented in the previous section. Besides habitat parameters other biological indices used include: algae dilution, sediment dilution, and winter kill risk. Algae dilution strongly influences water quality with high dilution equating to a higher probability of good water quality. High dilution was defined as elevations greater than 4142.5, moderate from 4141.5 to 4142.5, and low less than 4141.5. Sediment dilution strongly influences water quality with high dilution equating to a higher probability of good water quality. Criteria used for sediment dilution were high (>4141), moderate (4139-4141) and low (<4139). Criteria for winterkill risk include: high (<4139), moderate (4139-4140) and low (>4140).

On average, during <u>above average</u> water years, UKL lake levels may provide adequate habitat for shoreline spawning, emergent vegetation in the lower Williamson River and UKL for larval and age 0 juvenile sucker rearing, offshore deep-water for juvenile and adult suckers, and refuge areas near freshwater inflows. Water depths may be sufficiently deep to reduce the probability of large algae blooms and associated poor water quality. Depths may also are high enough to reduce the probability of poor water quality associated with bottom sediments. The risk of winterkill appears to be low.

However, the lowest monthly elevations during <u>above average</u> water years may not be sufficiently high to provide adequate water quality and habitat for the suckers. Emergent vegetation habitat is reduced during June and July possibly resulting in a lower survival of sucker larvae and age 0 juveniles. Algae and sediment dilution are moderate to low from June through October leading to an increased risk of poor water quality that is harmful/lethal for endangered suckers. Also, there is a moderate risk of winterkill in December and January.

Evaluating the average elevations during <u>below average</u> years indicates that shoreline spawning areas, offshore deep-water habitat for juveniles and adult suckers, and water quality refuge areas may be adequate. However, emergent vegetation habitats in the lower Williamson and UKL are reduced during June and July potentially resulting in slower growth and lower survival of larval suckers. There is an increased risk of poor water quality because algae dilution was moderate in the summer and fall. Sediment dilution indices are also moderate suggesting an increased risk of poor water quality particularly low dissolved oxygen that may result in reduced sucker growth and survival. There appears to be a low risk of winterkill based on the average monthly values.

When <u>below average</u> year minimum lake levels are assessed, there are lake levels that may adversely affect water quality or sucker habitat. Very little emergent vegetation habitat is inundated in June and July in the lower Williamson River and UKL leading to lower growth and survival of sucker larvae. With low to moderate algae and sediment dilution from May to October there is an increased risk of poor water quality that may negatively affect sucker viability. Water depths in water quality refuge areas in August and September are less than 3 feet deep. Adult suckers may have to occupy areas with potentially harmful/lethal water quality. The winterkill index values are moderate to high in December and January.

During <u>dry</u> water years, shoreline spawning habitat, and offshore deep-water habitat for juveniles and adults may be adequate for suckers (average lake elevations). However, emergent vegetation habitat in the lower Williamson River and UKL in June and July are small. Adult water quality refuge habitat is less than 3 feet deep in September potentially forcing fish to occupy areas with poor water quality. Algae and sediment dilution index values are low to moderate from May to October suggesting that there were increased risks of poor water quality. The risk of winterkill is low based on the average elevations.

In <u>dry</u> years, habitat for shoreline spawning, larval and age 0 juvenile rearing, offshore deep-water areas for adults, and refuge areas are all potentially inadequate for UKL sucker populations assessing the minimum lake levels. Also, algae and sediment dilution during the summer are low resulting in an increased risk of poor water quality that may be harmful/lethal for suckers.

<u>Critical dry</u> years result in reduced shoreline spawning habitat, reduced emergent vegetation habitat for larval and age 0 juveniles, reduced offshore deep-water habitat for adult suckers, and reduced water quality refuge areas that may adversely effect sucker survival. Algae and sediment dilution indices are low indicating that there is a higher risk of poor water quality in UKL potentially having an adverse affect on sucker survival. There is a higher risk of winterkill than at higher lake levels.

Except during most <u>above average years</u> and some <u>below average years</u>, on-going UKL operations may lead to significant loss of shoreline spawning habitat, thus likely reducing spawning success of lake spawning stocks; lead to substantial loss of larval and juvenile sucker habitat during the spring and early summer, thus potentially reducing the frequency and magnitude of year class success of river and lake spawning fish; contribute to light and nutrient conditions that promote *Aphanizomenon flos-aquae* blooms, thus increasing the frequency and magnitude of stressful and potentially lethal water quality conditions and thus adversely affecting survival of all life history stages; contribute to poor water quality during algae decay cycles by reducing lake volume/bottom surface area ratios that influence dissolved oxygen and unionized ammonia concentrations and thus adversely affecting survival of all life history stages; contribute to loss of or reduction in access to water quality refuge areas adjacent to freshwater inflow areas which are important to ensure adult sucker survival; and contribute to poor water quality conditions during winter ice-cover conditions by reducing lake volume/bottom surface area ratios that influence dissolved oxygen and u-ionized ammonia concentrations and thus adversely affecting adult and juvenile survival. Additional effects include significant loss of all life stages, but especially larvae and age 0 juveniles through entrainment and prevent passage of suckers into areas of preferred habitat or to spawning areas thus reducing survival and reproduction. These potential adverse effects of implementation of the proposed action would cumulatively likely reduce the frequency and magnitude of year class success and development and adversely affect juvenile and adult survival, and prevent recovery.

7.2 Clear Lake

The Clear Lake Dam blocks upstream sucker movement for the Lost River into Clear Lake watershed and creates marginal winter habitat in up to 11 miles of the upper Lost River below the dam. Following the irrigation season, flow is cut off, leaving only a small amount of leakage in the river. Fish, including suckers and their predators, seek refuge in the shallow pools that remain. Dissolved oxygen in these pools can drop to low levels due to the relatively high concentrations of aquatic organisms living in them. Survival through the winter of suckers and other fish is unknown but is suspected to be low due to reduced water quality and increased predation. Small accretions from Rock Creek and the East Branch of the Lost River enter the river about 4 and 8 miles downstream, respectively.

Proposed water releases from Clear Lake Reservoir during critical dry years and a few below average and dry years, coupled with expected lake level declines from seepage and evaporation, may result in lowered reservoir elevations that have direct adverse effects to suckers, including: 1) a loss of reservoir surface area and associated sucker habitat, 2) isolation from spawning streams (Willow Creek) at surface elevations lower than 4524 as happened in 1992, 3) increased susceptibility to predation by pelicans, bald eagles, and other fish-eating birds, 4) susceptibility to winter kill, 5) decreased water quality, including increased water temperatures throughout the lake and decreased DO concentrations, 6) increased competition with other fish for food and space, and 7) increased risk of a disease outbreak that could lead to sucker die-offs.

Clear Lake can freeze over in winter, and the concentration of fishes in a small volume of water under ice cover may result in the depletion of DO and subsequent fish kills. In October 1992, the water surface elevation was 4519.3 before the onset of a hard winter, and no fish kills were observed, although sucker populations were in poor condition (i.e., low body weight, high parasite abundance) in the spring of 1993.

With an extended drought, Clear Lake has the potential to decline to elevations that may not be capable of sustaining sucker populations due to factors given in the paragraphs above. This is partially due to natural causes, but is exacerbated by irrigation withdrawals. With average inflow, evaporation, seepage, and average irrigation releases, Clear Lake will stabilize at a water surface elevation of approximately 4,529. During a sustained drought, such as the six years from 1987-1992, continued releases of 35,770 af (the average release) overdraft the reservoir until physical limitations of the basin reduce the amount of water that can be released. During prolonged drought conditions the lake level can continue to decline, due to evaporation and seepage, even if no water is released.

Reclamation developed a reservoir operations model for Clear Lake from which future storage can be predicted based on beginning storage, inflow, and outflow (Reclamation 1994). Model simulations indicates virtually no chance of total desiccation without water releases, since the lake level at the beginning of a drought would be high enough to prevent this. The simulations demonstrate that an October 1 surface elevation of 4,521 (the proposed operating floor) would result in a surface elevation of at least 4519.1 (the winter hard-floor) the following October approximately 95 percent of the time, if there are not irrigation releases. Therefore, if the lake level was at or near the operating floor of 4,521 on October 1 when a drought began, and no irrigation releases were made the following summer, the lake would reach the winter hard-floor during the second winter of the drought. Reclamation considered the effects of the proposed operating floor using actual droughts extending 2-5 years. Minimum elevations for 2, 3, 4 and 5-year droughts were 4517.9, 4519.7, 4518.65, and 4518.85, respectively.

Reclamation's use of Clear Lake Reservoir for Project purposes in addition to delivering water to Langell Valley and Horsefly Irrigation Districts would likely result in a greater frequency of low reservoir water levels. The effects of these operations cannot be assessed without more detailed information on the frequency and magnitude of Project releases that are not presented in this biological assessment. Reclamation is currently developing a long-term operations plan that would provide more detailed information.

7.3 Gerber Reservoir

Gerber Dam blocks all upstream sucker movement from the Lost River into the Gerber watershed and creates marginal winter habitat in up to 12 miles of Miller Creek, below the dam. Some suckers are also entrained at the outlet of Gerber Dam. Downstream flows in Miller Creek are shut off at the end of the irrigation season, usually in October. In the winter, approximately 1 cfs is released into Miller Creek to prevent the outlet valve from freezing. During the irrigation season, flows from Miller Creek are diverted into the North Canal irrigation system. Little flow from Gerber Reservoir, or Miller Creek, now reaches the Lost River at any time of the year (except during flood control releases), and there is little connectivity between sucker populations in the Gerber Reservoir watershed and the rest of the Lost River system.

In 1991 and 1992, Gerber Reservoir was drawn down to very low levels by irrigation releases, even with voluntary restrictions by Langell Valley Irrigation District. In October 1992, following a 6 year drought, Gerber Reservoir reached a minimum elevation of 4796.4 (< 1% of maximum capacity). Suckers in the reservoir at that time showed signs of stress including low body weight, poor gonad development, and reduced juvenile growth rates, even though mechanical aeration was used to improve water quality during the summer. Low dissolved oxygen conditions were documented during the summer months. While DO concentrations in the upper water column were 4-6 mg/l from May through mid September, concentrations near the bottom were consistently below 4 mg/l and reached a low of 1.1 mg/l in June. While sucker populations survived the 1992 water year, they were stressed, and they may not have survived a further extended drought or other conditions that could have reduced water quality.

In 1993 and 1994, a wet year with relatively high lake levels followed by a low lake level year, summer water quality conditions were much better than 1991-1992, which followed extended drought, and sucker populations were substantially more robust. However, DO concentrations dropped to less than 2 mg/l in August-October and were also low during ice-cover conditions in January and February. Winter DOs ranged from 3-6 mg/l in the top several meters to as low as 1.5 mg/l near the bottom. Water quality conditions in 1994, which was a low reservoir year were similar to 1993 (minimum elevation of 4806.6). In January and February, during ice-cover conditions DO concentrations were 6-11 mg/l in the upper 5-8 m but decreased to less than 1 mg/l at the bottom. Algae blooms occurred in July and August, with DO concentrations remained above 4 mg/l in the top 3-5 m but dropping much lower near the bottom of the water column.

Gerber Reservoir may be drawn too low, particularly during below average, dry and critical dry water years, reducing available habitat and stressing sucker populations. Extended periods of low water levels may reduce access to streams for spawning, reduce water quality to a level that physically stresses fish populations, increase competition and predation and increase the risk of fish die-offs.

Reclamation's use of Gerber Reservoir water for Project purposes in addition to providing water to Langell Valley Irrigation District would likely lead to a higher frequency of lower reservoir water levels. The effects of these operations cannot be assessed without additional detailed information on the frequency and magnitude of Project releases. Reclamation plans to address specific Project operations in a long-term operations plan under development.

7.4 Lost River Dams and Diversions

The proposed action includes the operation of three Project dams and numerous irrigation diversions on the Lost River. The dams include Malone, Wilson, and Anderson Rose. There are other diversion dams on the Lost River operated by Horsefly Irrigation District (Bonanza, and Harpold) and a private landowner (Lost River Ranch). Major Federal diversions include: West Canal, East Malone Lateral, Lost River Diversion Canal, and J-Canal. None of the dams (Federal, Irrigation District, private) have fish passage facilities, and none of the diversions are screened to prevent entrainment of suckers, and other fish, into the irrigation system. The impoundment behind the dams and the irrigation canals concentrate suckers, which are then subject to adverse declines in water quality or are trapped when water levels drop.

Malone Dam, located 11 river miles (rm) below Clear Lake creates a reservoir approximately two miles long. It is maintained full from April through September and then drained for the winter. Many fish become dispersed downstream when the reservoir is drawn-down. Others get entrained into the West Canal at the end of the irrigation season or remain in the River upstream of the dam. Flows in the Lost River in the reach below Malone Dam to Bonanza (about 20 rm) are maintained by small accretions from Rock Creek, East Branch of the Lost River, Miller Creek and local runoff. The habitat is relatively poor because much of this reach has been channelized and is shallow.

Bonanza Diversion Dam located just upstream of the town of Bonanza actually consists of two flashboard diversion structures, one on each side of an island. This facility is owned and operated by the Horsefly Irrigation District. Water levels are maintained approximately 3 feet higher from April through September to allow pump irrigation directly out of the Lost River. The reservoir created is approximately 2 miles long. Sucker spawning has been documented above this dam in Miller Creek and at the end of the West Canal where it spills back into the Lost River. Adult suckers from downstream areas may be restricted from reaching these spawning areas if they try to migrate after the boards have been installed. Adequate flows over the dams allow downstream migration of fish. Flows in the Lost River below this dam to Harpold Dam (3 rm) are maintained in the winter by Big Springs which has a total discharge of about 75 cfs.

Harpold Dam, owned and operated by the Horsefly Irrigation District, is located about 3 rm below the town of Bonanza on the Lost River. The dam creates reservoir habitat upstream through the irrigation season and a small pool through the winter that would not exist otherwise and allows a population of suckers to maintain itself in the Lost River. Relatively large numbers of shortnose suckers have been observed in this area and spawning activity has occurred in nearby Big Springs and is suspected in Buck Creek and the Lost River immediately below the Dam. Spawning habitat exists both upstream and downstream of the flashboard dam, but the dam has no fish passage facilities. Adequate flows over the dam allow downstream migration. During the non-irrigation season flows in this reach include the combined accretions of streams entering the Lost River above Big Springs and Buck Creek (at least 100 cfs).

At Lost River Ranch, another flashboard diversion dam is operated during the irrigation season by a private landowner. Again there is no fish passage facility and suckers below the dam do not have access to upstream spawning areas after the boards are installed in April. There are no provisions for downstream migrate at the dam. During the winter months flows are at least 100 cfs in this river reach.

Approximately 30 rm downstream of Bonanza is Wilson Reservoir. This relatively deep impoundment (15-25 feet deep) is lowered 3-5 feet during the fall and winter for flood protection. Again there are no fish passage facilities on the dam.

A number of fish kills have been reported from the Wilson Dam area of the Lost River. In the summer of 1993 and fall of 1999, a fish kill occurred in the LRDC below the Wilson Reservoir headgates. It is presumed that low DO conditions caused these kills when anoxic water from the Klamath River in 1993 and from the bottom of the thermally stratified reservoir in 1999 were delivered to the LRDC. Winter water quality in Wilson Reservoir also impacts suckers and have caused fish kills when DO concentrations drop to lethal levels below an ice cover as occurred in 1998. Poor water quality conditions in Wilson Reservoir apparently cause some suckers to move out of the reservoir into the LRDC or the Lost River upstream.

The Lost River Diversion Channel, which is diverted out of Wilson Reservoir, presently flows either east or west, depending on water demands in the Project and flood control needs. In winter, almost the entire Lost River flow is diverted into the LRDC. These waters then flow downstream into the Klamath River. Winter flows, beyond the capacity of the LRDC (3000 cfs), are spilled into the Lost River. As the irrigation season begins in spring, the

Station 48 Canal, downstream from the LRDC headgates, is used to deliver water from the LRDC to the lower Lost River to irrigate areas south of Klamath Falls. When Station 48 summer demands exceed westward flowing LRDC flows, excess irrigation demands are met with water withdrawn from the Klamath River (UKL). Thus, Klamath River waters typically flow eastward through the LRDC when irrigation demands are high (e.g., late spring-summer) and Lost River waters flow westward through the Channel when irrigation demands are low and after the growing season (e.g., early November through March). Additional waters from UKL may enter into the Lost River system, and thus into the LRDC, when excess and return flows drain back into the Lost River watershed from the B, E, and F canals.

The Lost River from Wilson Dam to Anderson Rose Dam (about 15 rm) is generally operated as a conveyance channel. Irrigation deliveries and return flows from several drains maintain substantial flows in the River during the irrigation season. During winter no water is typically released from Wilson Reservoir or the LRDC into the Lost River. Small accretions occur for local runoff. However, during high runoff events flows can reach hundreds of cubic feet per second. Little habitat exists for suckers in this shallow reach.

Anderson Rose Dam, located approximately 8 rm upstream from Tule Lake blocks access for spawning suckers to historic spawning areas in the Lost River near Olene and Bonanza. Water releases for sucker spawning at Anderson-Rose Dam required in the 1992 BO, were modified in a July 13, 1998 amendment from 50 to 30 cfs based on information provided by Reclamation in a June 11, 1998 letter. Reclamation monitored spawning runs at Anderson-Rose Dam again in 1999 and 2000. Adequate passage and inundation of spawning areas was provided. However, because the Lost River is relatively wide and shallow adult suckers are vulnerable to predation by pelicans and river otters. Poor survival of sucker eggs and larvae appear to be associated with degraded spawning substrate.

Dam spills and irrigation drain water returns occur during the April through October irrigation season provide varying flows in the river. Due to the low gradient and backwater effects, the lower Lost River remains inundated throughout the year providing some potential for juvenile sucker rearing habitat. During the winter months small flows occur in the lower Lost River from local run-off.

7.5 Tule Lake

Reclamation's proposed water level operations in the Tule Lake sumps remain the same as those identified in the 1992 BO. There are no short-term opportunities to operate the sumps at higher levels without major risk of overtopping existing dikes. Continued filling in of the sumps with sediment appears to be a major factor affecting sucker populations. Shallow depths are marginal for adult suckers and winterkill is a threat during ice cover conditions during all years. Also, the sumps lack emergent wetland habitat presumably important for larval and juvenile sucker rearing areas. Reclamation and the Service support wetland/agricultural land rotation as a management strategy to increase water depth and improve lake habitat conditions for suckers. A pilot program was initiated a few years ago and implementation of this program is anticipated in the next few years.

7.6 Keno Reservoir

Besides the indirect effects of Project operation on water quality related to reservoir operations, water quality in Keno Reservoir is directly affected by water discharged from the Klamath Straits Drain (KSD) and the Lost River Diversion Canal (LRDC). Diversions from the LRDC to Keno Reservoir occur mostly during the winter when water quality conditions are adequate in both the Lost River and Keno Reservoir. During summer storm events, Lost River water with low dissolved oxygen concentrations can be diverted into Keno Reservoir. A technical memorandum prepared in 1995 reviewed technical information available at that time and summarized the effects on water quality (CH2M HILL 1995).

The major conclusions of the study include: 1) the KSD dominates the hydrology of the Keno Reservoir during dry years and in the spring months when UKL is filling and KSD is discharging to the reservoir (the Drain can contribute between 20 and 100 percent of the inflow to Keno Dam), 2) because the KSD discharge can be such a large proportion of the flow at Keno, the quality of the Drain water has significant effects on the reservoir water quality in the reach from the Drain to Keno. Depending on the nature of the water quality parameters of concern, the high proportional discharge may affect locations downstream of Keno, 3) the effect of Project discharges on the temperature regime downstream are low, and 4) low dissolved oxygen levels in Keno Reservoir above the Drain, due primarily to high sediment oxygen demand, has the largest influence on DO levels in Keno Reservoir.

Reclamation participated in the Klamath River TMDL process lead by Oregon Department of Environmental Quality from 1997-1999. Reclamation has collected water quality data at KSD quarterly since 1984, in compliance with an Environmental Impact Report prepared for the enlargement of KSD. From 1992-1997 Reclamation collected extensive Hydrolab data from 13 sites between Link River and Keno Dam. During 1999 and 2000, detailed hydrolab and water chemistry data was collected from several locations between Pumping Plant D and the Straits Drain. Reclamation has not performed a detailed analysis of the water quality data. We have recently contracted with David Evans and Associates and Mike Deas to help with the data analyses.

7.7 Fish Passage

Link River Dam has a fish ladder to provide fish passage between Link River/Lake Ewauna and Upper Klamath Lake. A study was conducted by PacifiCorp and Oregon Department of Fish and Wildlife from 1988 through 1991 to evaluate the status and effectiveness of fish passage at this and other fish ladders (PacifiCorp 1997, Hemmingsen et al. 1992). Few suckers have been documented using the Link River Dam fish ladder. The trap in the fish ladder collected only four adult shortnose and two adult Lost River suckers from 1988 through 1991. All of these suckers were caught in April and May of 1989. During the four-year sampling period, 131 redband trout were collected, with most collected in 1989. In June 1996, several adult suckers were observed at the entrance and in the lower pools of the ladder (Frank Shrier, PacifiCorp, per. com.).

Very low use of the fish ladder appears to be related to operational procedures, inadequate passage facilities, and a fish barrier located downstream of the dam. PacifiCorp conducted a study in 1990 to identify actions that could be implemented to improve fish passage at Link River Dam (Ott Engineers 1990). The Link River fish ladder is impassable when Upper Klamath Lake levels drop below 4138.5 feet.

Inadequate fish passage facilities at Link River Dam leads to adverse effects that result from genetic isolation through segregation of populations. Also, fish that are entrained through Link River Dam facilities are unable to return to UKL and are exposed to poor habitat conditions in Keno Reservoir or get diverted into irrigation systems supplied by the Lost River Diversion Canal, North Canal, Ady Canal and other diversions.

None of Reclamation's dams including Clear Lake, Gerber, Miller Creek, Malone, Wilson, and Anderson-Rose have fish passage facilities. Therefore, entrained fish are unable to return to the reservoirs and populations are segregated. Some fish that pass the dams are salvaged, others become distributed downstream, and some perish when habitats below the dams become dewatered or fish are diverted into irrigation delivery systems. Hybridization between sucker species may occur at higher frequencies because spawning fish are restricted to spawning areas below dam facilities.

7.8 Entrainment

There are numerous water diversions associated with the Klamath Project. These diversions are structures that divert water by using gravity flow or electrically powered pumping stations (Reclamation 1992a). Currently there are no permanent devices or measures being utilized at the diversion sites to prevent fish entrainment. At Clear Lake Reservoir, a large barrier net has been placed in the forebay during the irrigation season to reduce entrainment since 1993. A 1-inch square mesh net was used from 1993-1998 and a ¾-inch square mesh net used in 1999 and 2000. Based on end of season salvage of fish from the dam outlet, the net placement appeared to be fairly effective in reducing loss of juvenile and adult suckers (Reclamation 2000b). From 1993 through 1999 number of suckers salvaged ranged from 10 to 292 with catches in most years less than 60 fish. However, in 2000 when additional releases were made in September beyond normal deliveries to LVID and HID, 587 suckers were salvaged below the dam including 357 adults (Reclamation 2001). Releases in September 2000 exceeded 500 cfs while normal irrigation deliveries are 100-150 cfs.

At Malone Dam, avian wire barriers (1 1/4-inch square mesh) was installed in 1993 and replaced in 1994 and 1999 at the head end of the West Canal and East Malone Lateral. These barriers have been maintained by Langell Valley Irrigation District. Only 6 age 0 suckers were salvaged from the West Canal in 1999 (Reclamation 2000b).
In 2000, 6 age 0 and age 1 juvenile suckers were salvaged (Reclamation 2001).

At Agency Lake Ranch, a ¼-inch delta mesh barrier net has been used to reduce entrainment in 1998 and 2000. We also monitored the effectiveness of the barrier net using a rotary trap in 2000. Captured fish were released into Agency Lake after data was collected from them.

Entrainment of suckers has been observed in many locations throughout the Project. Most of the large diversions in the Klamath Project are gravity diversions associated with storage reservoir and diversion dams. These include: Clear Lake Dam, Gerber Dam, Malone Dam, Miller Creek Diversion Dam, Wilson Dam, Link River Dam, and Anderson Rose (Reclamation 1992a). Reclamation inventoried most diversions in the Klamath Project service area below UKL (Reclamation 2000d). Reclamation identified 193 diversions within the Klamath Project service area that were directly connected to endangered sucker habitat below UKL. Federal, state, private and irrigation district water diversions in the Klamath Project Service area include: 21 (11%), 8 (4%), 122 (69%), and 26 (14%), respectively. The only diversions with fish screens include three sites on the Klamath River associated with the Miller Island Wildlife Area.

Most diversions are operated during the irrigation season from April through September/October. There are several notable exceptions including all storage reservoirs that are operated for flood control. Flood control releases typically occur during the winter and spring and can be quite high. For example, the Lost River Diversion Canal has been operated at its capacity of 3,000 cfs in recent years and flood releases have been as high as 10,000 cfs from Link River Dam. Two power diversions, on Link River Dam can be operated throughout the year depending on water availability.

With the exception of the A-Canal and PacifiCorp's Eastside and Westside power diversions at Link River Dam, quantitative data on entrainment is lacking. However, a qualitative assessment was performed by Reclamation for diversions in the Klamath Project service area (Reclamation 2000d). Gravity diversions are considered to have a greater potential for entrainment than pump diversions. They are typically operated for a longer period of time with more total volume diverted. Irrigation and flood releases from Clear Lake and Gerber reservoirs have potentially high entrainment losses because of the inability to conduct effective salvages when releases are cut off. There are approximately 11 and 13 miles of river habitat below Clear Lake and Gerber reservoirs. Salvage operations are not typically performed in Miller Creek when irrigation deliveries are shut off at Gerber and only limited fish salvage is performed immediately below Clear Lake Dam.

Many diversions have relatively high flows but are connected to permanent sucker habitat and not dewatered. These include the Lost River Diversion Canal, Ady Canal, North Canal, Station 48, and Eastside and Westside power diversions. Therefore, fish can inhabit the diversion canal or the receiving water. However, the receiving waters are frequently poor fish habitat areas.

Diversions also have different potential for entrainment based on there location related to sucker distributions. Highest sucker abundances are associated with UKL, Gerber Reservoir, and Clear Lake. Low sucker abundances occur in Tule Lake and Keno Reservoir. In Keno Reservoir, sucker abundance is higher near Link River and lower from Miller Island to Keno. Higher abundances in the upper portion of the reservoir are associated with better water quality and habitat and high entrainment of suckers from UKL. Therefore, the Lost River Diversion Canal has a higher potential for entrainment due to its close proximity to Lake Ewauna than the Ady Canal that is downstream.

In the Lost River, suckers are more abundant in the Bonanza to Harpold Dam reach and Wilson Reservoir. Low population densities occur in the river between Malone Reservoir and Keller Bridge and below Wilson Dam to Anderson Rose Dam. Again, diversions in areas of high sucker abundance have a higher potential for entrainment than low sucker abundance areas.

Significant larval sucker entrainment into the A-Canal was recorded during studies done in 1990, 1991, and 1996-1998 (Markle and Simon 1993, Gutermuth et al. 1998, Gutermuth et al. 2000a). A-Canal larval entrainment in 1990 was estimated at approximately 400,000. Larval entrainment was likely greatly underestimated in this study because sampling began too late in the season after much of the entrainment was suspected to occur, and no monitoring was done at night, when larval sucker movement appears to be highest. In 1991, entrainment was estimated at 800,000 sucker larvae, and in the more complete studies (1996-1997) entrainment estimates for larval and early juvenile suckers was 3 million and 1.7 million, respectively.

Studies designed specifically to quantify juvenile and adult sucker entrainment into the A-Canal were conducted in 1997 and 1998 (Gutermuth et al. 2000a). The total 1997 A-Canal entrainment index was estimated at 47,000 juvenile and adult suckers. The 1998 entrainment index was 250,000 suckers, due to an increase in Age 0 juveniles in the collections. For both years, the majority of suckers were caught in August (75% in 1997 and 70% in 1998), with most of the remainder caught in September. In August-September 1997, entrainment rates of large suckers (>15 cm FL) were considered primarily the result of stressed and debilitated fish moving from severely degraded water quality conditions in UKL during a fish kill. However, numerous Age 0 juveniles in relatively good condition were also collected at that time. Consequently, the increased late-summer catches may, when combined with similar 1998 patterns, suggest an annual movement pattern of primarily juveniles out of UKL and down the Link River.

Sucker entrainment studies were also conducted at the two hydroelectric diversions on Link River Dam in 1997, 1998, and 1999 (Gutermuth et al. 2000b). Suckers were most common in August and September, with higher entrainment rates after the A-Canal was shut down. An average of about 50,000 suckers per year were entrained in the diversions. Nearly all were juveniles, with about 75% under 7.5 cm FL and 25% 7.5-15 cm FL; only 1% of the suckers caught were over 15 cm FL. These estimates combined with the A-Canal are of similar magnitude to the Fall Age 0 juvenile population estimates obtained by OSU in their studies of UKL populations, suggesting that the combined Link River and A-Canal facilities are entraining a high percentage of the juvenile suckers produced annually in UKL.

Reclamation has conducted sucker salvage operations at the end of the irrigation season annually since 1991 as required by the 1992 Biological Opinion (Reclamation 2000b, 2001). The numbers salvaged ranged from 334 to 26,928 suckers per year. From 1996-2000, the numbers of suckers salvaged were 11,000 (1996), 2,400 (1997), 2,700 (1998), and 27,000 (1999), and 8,700 (2000). Age 0 suckers dominated the 1996, 1998, 1999, and 2000 salvage catches and age 1+ juveniles dominated in 1997. Very few adult Lost River and shortnose suckers have been salvaged from Project canals. These numbers are substantially lower than those indicated in the above entrainment studies and may suggest that salvage is not a very effective alternative.

Reclamation's proposed action calls for continued diversion of water for irrigation from Upper Klamath Lake through the A-Canal, Klamath River through the Lost River Diversion Channel, the Lost River and also from Tule Lake to Lower Klamath Lake via Pumping Plant D. These and other Project diversions that are directly connected to sucker habitat (Reclamation 2000d) have substantial adverse impacts on the suckers (especially the larval suckers and young of the year juvenile suckers) by direct mortality through the pumps, or mortalities through desiccation, aquatic plant control, Cell Tech's algae harvest operations, predation, and poor water quality associated with the canal systems. Reclamation through its contractors (irrigation districts) have implemented measures to reduce stranding in canals at the end of the irrigation season and is planning to install a fish screen facility on the A-Canal by 2002 as directed by an amendment to an RPA in the 1992 BO. Reclamation proposes to continue to assess and develop an entrainment reduction plan prioritizing sites based on relative impacts to the species. Reclamation has conducted and proposes to continue annual salvage operations in Project canals to reduce incidental take.

8.0 PROPOSED CRITICAL HABITAT FOR SHORTNOSE AND LOST RIVER SUCKERS

On December 1, 1994, the Service published a proposed rule for Lost River and shortnose suckers critical habitat (USFWS 1994a). A total of six critical habitat units (CHU) were proposed comprising a total of approximately 456,000 acres within the Upper Klamath Basin, California and Oregon (59 FR 61744). These proposed Lost River and shortnose sucker CHUs are areas which have been determined by the Service to have the physical and biological features: 1) essential for the conservation of the species; and 2) which may require special management considerations or protection.

The physical and biological features (or primary constituent elements) essential to the conservation of these species include water, physical habitat, and biological environment. These primary constituent elements support Lost River and shortnose suckers' spawning, foraging, cover, refugia and corridors between these areas, growth, and dispersal (59 FR 61744). Water includes a quantity of sufficient quality (i.e., temperature, dissolved oxygen, pH, lack of nutrients, turbidity, etc.) that is delivered to a specific location in accordance with a hydrologic regime that is required for each life stage. Included in the water element are those physical and structural features of a functioning watershed. Physical habitat includes areas that suckers use for refugia, spawning, nursery, feeding, rearing, other normal behavior, and as corridors between these areas. Biological environment is the food supply, predation, parasitism, and competition associated with the various sucker life stages.

The Klamath Project lies within or adjacent to all six of the proposed critical habitat units: CHU #1 (Clear Lake and Watershed); CHU #2 (Tule Lake); CHU #3 (Klamath River); CHU #4 (Upper Klamath Lake and Watershed); CHU #5 (Williamson and Sprague Rivers); and CHU #6 (Gerber Reservoir and Watershed). Primary constituent elements associated directly and indirectly with Reclamation's operations for these units are as follows:

> Clear Lake and Watershed: Water quality (i.e., pH and dissolved oxygen) in Clear Lake Reservoir is generally not limited, however, of major concern is low reservoir elevations with associated loss of habitat and warm water temperatures, reservoir elevations affecting passage from Clear Lake Reservoir into the single spawning tributary system (Willow Creek), and non-native, predaceous fish.
>
> Tule Lake: The Klamath Project's potential impacts to CHU #2's primary constituent elements include degraded water quality contributions via nutrients and pesticide use, reduction in spawning and rearing habitat in the Lost River, minimal deep water habitat within the Tule Lake sumps, and spawning flow magnitude and duration below Anderson-Rose Dam.
>
> Klamath River: CHU #3's primary constituent elements might be affected by Klamath Project operations through alterations in flow timing, magnitude, and duration, establishment of non-native fish species, and water quality degradation (i.e., temperatures, pH, dissolved oxygen). Additionally, peaking releases from downstream reservoirs might impact sucker spawning and subsequent larval/juvenile lifestage activities.
>
> Upper Klamath Lake and Watershed: Klamath Project's management of Upper Klamath Lake's water surface elevations has numerous potential direct and indirect affects to CHU #4's primary constituent elements. Of greatest concern are potential impacts to shoreline spawning areas, water quality degradation (i.e., pH, unionized ammonia, dissolved oxygen), fish kills, loss of water quality refuge areas, impacts to young-of-the-year shoreline rearing areas, segregation of habitats, and impacts (i.e, predation, competition) from non-native fish species.
>
> Williamson and Sprague Rivers: The only Klamath Project relationship to CHU #5's primary constituent elements would be water level management and its associated impacts on access to the Williamson River for spawning, larval emigration and quality of rearing areas, and access to water quality refuge areas.
>
> Gerber Reservoir and Watershed: Water surface elevation management at Gerber Reservoir has potential impacts to primary constituent elements in CHU #6. Water quality can be degraded at lower reservoir elevations, access to spawning tributaries may be reduced, and reservoir management may benefit non-native fish species which compete with or prey on suckers.

Section 7 of the Act requires Federal agencies to insure against the destruction or adverse modification of critical habitat; section 7(a)(4) of the Act requires Federal agencies to confer with the Service on any action that is likely to result in the destruction or adverse modification of proposed critical habitat. Reclamation has reviewed the potential impacts of the Klamath Project's proposed operations, which includes implementation of the reasonable and prudent alternatives from prior biological opinions (July 22, 1992 and August 11, 1994), on the primary constituent elements of proposed critical habitat and has determined that the proposed action is likely to adversely affect proposed critical habitat. A justification is provided below for each constituent element. Reclamation formally requests conference on the effects of the proposed action, including the implementation of the reasonable and prudent alternatives from prior biological opinions, on proposed critical habitat for the Lost River and shortnose suckers; Reclamation believes that the proposed action may adversely modify proposed critical habitat.

> Water: Water quality is perhaps the most crucial primary constituent element to proposed critical habitat (USFWS 1994a). Reclamation's proposed operations may cause water quality problems in Clear Lake (CHU #1), Tule Lake (CHU #2), Klamath River (CHU #3), Upper Klamath Lake (CHU #4), and Gerber Reservoir (CHU #6). However, the proposed action, including implementation of the reasonable and prudent alternatives from prior biological opinions that establish water elevation requirements for Clear Lake, Tule Lake, Upper Klamath Lake, and Gerber Reservoir, reduce the Project's impacts on water quality.

These positive steps towards reducing impacts, still result in an action that is likely to adversely affect proposed critical habitat.

Physical Habitat: Reclamation's proposed action will allow water elevation manipulation in Clear Lake (CHU #1), Tule Lake (CHU #2), Klamath River (CHU #3), Upper Klamath Lake (CHU #4), the lower Williamson River (CHU #5) and Gerber Reservoir (CHU #6). Possible impacts to this primary constituent element include reduction in fish passage corridors, alteration in littoral shoreline vegetation, and reductions in water quality refuge areas. Reclamation believes that the proposed action, with its associated water elevation operations, may not reduce the ability of listed sucker species to ascend the following primary spawning tributaries during most water years: Willow Creek (CHU #1); Lost River (CHU #2); Williamson/Sprague and Wood Rivers (CHU #4 and 5); and various tributaries to Gerber Reservoir (CHU #6). These water elevations may also ensure adequate movement corridors for normal behavior. However, access to Willow Creek (CHU#1), and Gerber Reservoir tributaries (CHU#6) may likely be blocked during critical dry years, and a few below average and dry years. Additionally, the proposed action may not provide adequate inundation of in-lake shoreline spawning areas and suitable conditions for sucker access and spawning in these habitats during critical dry and some dry years in Upper Klamath Lake (CHU #4). Reclamation believes their proposed action may have a negative effect on littoral shoreline vegetation habitat in Upper Klamath Lake during below average, dry and critical dry years. Reclamation also believes the proposed action may not ensure adequate depth in areas adjacent to freshwater inflows that serve as water quality refuges, will occur during critical dry years and some below average and dry years.

Biological Environment: The main concern regarding effects of Reclamation's proposed action on this primary constituent element is enhancement of non-native fish populations (USFWS 1994 draft). Reclamation's research indicates that non-native predation and/or competition is probably not a major concern in Clear Lake (CHU #1), Tule Lake (CHU #2), or Gerber Reservoir (CHU #6). However, recent research indicates water level management in Upper Klamath Lake (CHU #4) could be used to reduce non-native fish competition and/or predation (Klamath Tribes 1995). Reclamation believes the proposed action may not reduce potential adverse interactions between listed suckers and non-native fishes during critical dry, and some dry and below average years. Reclamation also believes sucker die-offs may occur under the proposed action particularly during below average, dry and critical dry years.

9.0 CUMULATIVE EFFECTS

Cumulative effects are those effects of future non-Federal (State, local governments, or private) activities on endangered and threatened species or critical habitat that are reasonably certain to occur within the action area of the Federal activity subject to consultation.

9.1 Clear Lake Watershed

Most of the land in the Clear Lake watershed is Federally owned and actions affecting listed species will undergo section 7 consultation and thus are not considered in this section. Remaining land is in private ownership and is mostly open juniper-bunchgrass rangeland with some small forest areas of ponderosa pine. Few people live in the area. Reclamation anticipates that most of this land will be used as it has in the past as range (grazing) and forest (logging).

Private land grazing in the Clear Lake watershed is not considered to be a significant threat because limited areas of private rangeland are located in the watershed. Grazing in the Clear Lake watershed has previously destabilized streambank vegetation resulting in erosion, siltation, reduced quality of gravel and cobble spawning areas, increased water temperatures, wider and shallower stream channels, and lowered water tables. The Water Users Plan (Klamath Basin Water Users Protective Association 1993) suggest that significant opportunities exist to improve riparian habitat in the Clear Lake/Lost River/Gerber Reservoir drainage. Conditions of rangelands are anticipated to continue to improve with proactive management.

Forestry practices may also contribute to water quality declines in the upper Clear Lake watershed, but because commercial forest comprise such a small area and will be infrequently harvested that Reclamation does not consider forestry a significant threat in this watershed.

Introduced fishes such as brown bullhead, fathead minnow, Sacramento perch, pumpkinseed, green sunfish, bluegill, and largemouth bass have been accidentally or intentionally introduced in the Clear Lake watershed. Because relatively stable sucker populations co-exist with abundant non-native fish populations in Clear Lake and its tributaries, Reclamation does not consider exotic fish to be a major threat.

Transportation of hazardous materials along roadways in the Clear Lake watershed and use of herbicides, and pesticides appear to be a small risk owing to their infrequent presence in the watershed.

9.2 Gerber Reservoir Watershed

There are six private water developments in the Gerber Reservoir watershed (Reclamation 1970c). These developments are used primarily for livestock operations. Approximately 13,300 acres of both privately held and Forest Service permitted land are included in these developments. Each of these operations use a combination of dams, reservoirs, and ditches to distribute water or use dikes, ditches and canals to irrigate their lands for pasture and hay, and grain cultivation.

The effects of these impoundments on the shortnose sucker populations in the Gerber Reservoir watershed are unknown. During periods of above-average precipitation suckers are suspected to occupy some of these impoundments. Water storage may increase instream flows during the summer. The impoundments also may trap sediments keeping them out of downstream pools and riffles where suckers reside or spawn. The net effect of these developments may be neutral or even beneficial to suckers.

Land use in the Gerber Reservoir watershed is similar to that of Clear Lake, perhaps with more commercial timber on private lands. Forestry and grazing that follow established best management practices are not considered to be a significant threat to shortnose suckers in the Gerber Reservoir watershed.

Introduced fish including fathead minnows, yellow perch, crappie, brown bullhead, largemouth bass, pumpkinseed, and green sunfish have been accidentally or intentionally introduced in the Gerber Reservoir watershed. Because relatively stable shortnose sucker populations co-exist with abundant non-native fish populations in Gerber Reservoir, Reclamation does not consider exotic fish to be a major threat.

Transportation of hazardous materials along roadways in the Gerber Reservoir watershed and use of herbicides and pesticides appear to be a small risk owing to their infrequent presence in the watershed.

9.3 Lost River and Tule Lake Sumps

The Tule Lake sumps are affected by adjacent land uses and upstream water quality in the Lost River and Klamath River. Most of the water reaching the sumps during the irrigation season is agricultural return water originating from Upper Klamath Lake delivered through the Lost River Diversion Canal and Station 48. Reclamation anticipates that Refuge lease lands will contribute nutrients, sediment, herbicides and pesticides to the Tule Lake sumps that may affect listed suckers. Pesticides, herbicides and fertilizer use on the lease lands has undergone section 7 consultation. The indirect effect of sediments from the lease lands has not been consulted on.

Most of the low-lying land in the valleys adjacent to the Lost River (Langell Valley, Yonna Valley, Poe Valley) are privately owned and used for agriculture. These lands contribute nutrients, sediment, fertilizers, herbicides and pesticides to the Lost River and the Tule Lake sumps that will affect listed suckers. Many of these lands receive water from the Klamath Project. Several dairy operations are found in the Langell and Poe Valleys that contribute nutrients to the Lost River. Additionally, nutrients from residences along the River and sewage treatment facilitities in Bonanza, Merrill, and Tule Lake on occasion make there way into the River. Other potential sources of nutrients include a feed processing plant in Merrill and food processing facilities in Hatfield.

9.4 Upper Klamath Lake Watershed

Private landowners along streams tributary to UKL annually exercise their State of Oregon rights to withdraw water for irrigation and livestock watering. The total amount of water that is annually withdrawn before it reaches UKL has not been determined but it is thought to be substantial. It is estimated that about 186,000 acres benefit from diversions above the Klamath Project boundaries. Nutrient enriched return flows from these upstream agricultural lands coupled with the reduced inflows to the lake, because of irrigation depletion, likely contribute to the eutrophication in UKL. The resulting lowered water level and poor water quality may affect all three listed species considered in this BA.

Despite high background total phosphorus (TP) levels in UKL tributaries and springs (Kann and Walker 1999, Rykbost 1999), data exists from several studies to indicate that TP loading and concentrations are elevated substantially above these background levels. One of the earliest nutrient loading studies (Miller and Tash 1967) indicated that despite accounting for only 12% of the water inflow, direct agricultural input from pumps and canals account for 30% of the annual external TP budget. Other studies show that drained and diked wetlands consistently pump effluent containing 2-10X the phosphorus concentration of tributary inflows (Reclamation 1993a, 1993b), and nitrogen and phosphorus are liberated from drained wetland areas, leach into adjacent ditches, and are subsequently pumped to the lake or its tributaries (Snyder and Morace 1997). Coupled with the considerable but diffuse non-point contribution stemming from wetland loss, flood plain grazing, flood irrigation, and channel degradation, the TP input from anthropogenic sources likely accounts for a greater percentage than that indicated by the 30% contributed due to direct pumping alone. Gearheart et al. (1995) estimated that over 50% of the annual TP load from the watershed could be reduced with management practices, and Anderson (1998) likewise estimated that in-lake TP concentration could be reduced by utilizing watershed management strategies. Walker (1995) also estimates that an increase in Agency Lake inflow concentration from approximately 80 to 140 ug/l (40%) is an estimate of the anthropogenic impact.

The Williamson River and Wood River together accounted for 67% (48% and 19%, respectively) of the 1992-1998 TP load; with springs, ungaged tributaries contributing another 10%. Precipitation, Sevenmile Canal and agricultural pumping accounted for the remaining 23% (Kann and Walker 1999). Unlike water contribution, where Wood River, Sevenmile Canal, and pumps contribute 25% of the water load, these same sources contributed 39% of the average annual TP load. In contrast, springs contributed 16% of the water input, but contributed only 10% of the TP load. This appears to be partially due to the consistently higher volume weighted TP concentration occurring in the pump effluent, and Wood River and Sevenmile Canal systems.

The estimate of anthropogenic contribution of TP loading for all 7 water years is 40% with a range of 36% to 45% for individual years. These values are very similar to the 40% anthropogenic TP contribution estimated by Walker (1995) for Agency Lake.

TP loads during the 1992 and 1994 drought years were 62% of the 1992-1998 average. The 1993 water year is of note because while flow was 108% of the 7-year average, TP load was 114% of the average. Other years (with the exception of 1996) tended to have percentage of average TP loads lower than their respective percentage of average water inputs. It may be that additional nutrients flushed in a following high flow year. Moreover, the volume weighted TP concentration of the Sprague River watershed is impacted by wetland and riparian loss, flood plain grazing, agricultural practices, and channel degradation, it would be prone to TP export, especially during major runoff events.

An estimate of the particulate phosphorus (PP) load was taken as the TP load minus the soluble reactive phosphorus (SRP) load. These data clearly show an increase in the loading of particulate phosphorus (PP) during high runoff events for the Williamson and Sprague Rivers. During these high flow events, which typically occur from January-May, PP can increase to 60% of the TP load, compared to less than 5% during summer low flow periods. There are also noticeable spikes of PP load occurring in the Wood River and Sevenmile Canal systems, but they are not limited to high runoff periods. This pattern could be consistent with flood irrigation practices that would tend to be pulsed in nature, and where overland runoff could increase the proportion of particulates. The increase in TP and PP loading are both indicative of degraded watershed conditions. In a healthier watershed (e.g., intact riparian areas and flood plains) the concentration should tend to decrease at high flows through dilution, and particulate loading should only increase slightly (Kann and Walker 1999).

Eiliers et al. (2000) using paleolimnology techniques examined nutrient content of UKL sediments over the past 1000 years. Based on a variety of analyses they determined that sediment accumulation rates and levels of phosphorus in sediment had increased in the past 150 years. They attributed these increases to anthropogenic watershed effects, such as forestry and agriculture. Their results were consistent with those of Coleman and Bradbury who found increased amounts of tephra, volcanic ash in recent UKL deposits (USGS, unpub. data).

There are approximately a dozen large unscreened diversions in UKL that supply water to about 15,000 acres of agricultural lands and restored wetlands around UKL. These diversions will likely continue to entrain substantial numbers of larvae and juvenile suckers.

Approximately 15,000 acres of drained wetlands around UKL are being restored. The immediate benefit from these lands is that management will emphasize water quality improvement in UKL. Management actions on these lands that once contributed nutrients to UKL have been stopped or significantly reduced. Restoration on the Running Y Ranch Resort includes up to 1000 acres of marsh habitat. Other activities likely to occur include large-scale riparian restoration along the major tributaries of UKL through fencing and improved grazing practices, and wetland restoration. The Nature Conservancy recently purchased Tulana and Goose Bay Farms, 8,000 acres at the mouth of the Williamson River. Acquisition and restoration of this property has great potential for restoring sucker habitat, and improving water quality in UKL. TNC has also purchased an additional 7,000 acres at Sycan Marsh expanding its preserve to over 25,000 acres. This acquisition and restoration of the Marsh should improve water quality and hydrologic function in the Sycan and Sprague Rivers, tributaries to UKL.

9.5 Agency Lake and Wood River Watershed

Numerous ranches in the Fort Klamath area divert significant quantities of water out of the various streams and springs in the watershed upstream and adjacent to Agency Lake north of UKL. The natural streams in this area include: Sevenmile Creek, Fourmile Creek, Annie Creek, Crooked Creek, and the Wood River. Additionally, water from various natural springs is diverted to various maintained ditches that supply irrigators in the area. Major ditches conveying water from the natural creeks and springs to the irrigators include: Bluespring, Sevenmile, and Melhase Ditches. Return flows from these ditches are collected into several canals that connect with and are adjacent to Agency Lake. These canals contain water year round and include: West, Sevenmile, Central, and North Canals among others. The Meadows Drainage District and many individual landowners divert water through the aforementioned ditches.

Juvenile Lost River and shortnose suckers are known to occur in the Wood River and Crooked Creek (D. Markle, OSU, per. com.). It is suspected that some of these suckers may be spawning in these tributaries to Agency Lake. In larval distribution and abundance studies at the confluence of the Wood River and Agency Lake in 1991, investigators collected larval suckers indicating that suckers were using the Wood River drainage for spawning habitat (Logan and Markle 1993). Depending on how far these spawning fish migrate upstream in the Wood River and Crooked Creek, the adult spawners, embryos, and emerging larvae of these suckers may be impacted by water diversions from these tributaries. If spawning suckers are in downstream reaches of the Wood River and Crooked Creek below irrigation diversions when water deliveries to the ditch systems are diverted out of the channel, then the spawning behavior of these fish may be disrupted resulting in no sucker spawning in that year.

In 1991, Logan and Markle (1993) found that larval suckers were emigrating through the lower Wood River into the confluence with Agency Lake in late July. This corresponds to the approximate peak of water diversion (June-mid August) from the Wood River and Crooked Creek (D. Sparks, Klamath County Watermaster, per. com.). Therefore, if suckers succeed in spawning within the reaches upstream of the diversion ditches, the embryonic and emergent life-stages would potentially be subject to diversions into canals and fields, reduced flows and resulting elevated water temperatures during incubation and larval emigration.

In addition to the potential direct impacts on sucker populations of the diversion of water into irrigation ditches upstream of Agency Lake, potential indirect impacts of these diversions are possible. As was previously noted, a large portion of the water diverted to the irrigation ditches is recovered to the streams as return flows.

Depending on land practices, use of fertilizers, herbicides, and other chemicals, the number of reuses, and erosion in this agricultural area, the water quality (including dissolved oxygen, turbidity, and temperature) of these return flows could range from fair to poor. The return water, upon collection in the downstream canals, could then potentially impact the water quality of the marsh and near-shore habitats of larval, juvenile, and/or adult suckers or other fishes present. It is known that young life stages of suckers frequent these and other habitat types in UKL. Vincent (1968) found that approximately 80% of suckers sampled in his study areas were collected in either marsh or rocky shoreline habitat as compared to mid-lake sampling locations. Vincent (1968) determined that of approximately 20 miles of shoreline habitat in Agency Lake, 9.5 miles were marsh shoreline habitat. Markle (OSU, per. com.) found that in their sampling, Agency Lake was devoid of larval and young-of-the-year suckers after late summer. The inability to collect larval suckers indicates that the larval suckers sampled at the Wood River confluence earlier in the summer had either: a) migrated out of Agency Lake, b) there were so few recruited into the Lake that their abundance was minimal and could not be detected by sampling, or c) that no larval suckers survived in Agency Lake after mid-summer. Nutrient rich irrigation return water reaching Agency Lake could result in algae blooms and anoxic conditions within Agency Lake itself. These noxious blooms and resulting degraded water quality could potentially result in fish kills in Agency Lake during the late summer months.

9.6 Williamson River Watershed

In the Upper Williamson River watershed, past grazing and forestry practices have adversely affected stream morphology, with the result that the river has become entrenched. Agricultural practices in the drainage could have the same effects as those listed above for the Agency Lake drainage. Private landowners have taken measures to improve watershed conditions in recent years through proactive land management.

Unscreened irrigation diversions on the lower Williamson River in the area of concentrated larval migration and rearing may be reducing sucker recruitment to UKL. Irrigation diversions also reduce stream flows. Residential development along the lower Williamson River could adversely affect riparian areas when native vegetation is removed and stream banks are modified. These developments may also contribute nutrients through septic tank leaching, and fertilizer runoff from lawns.

9.7 Sprague River Watershed

Chiloquin Dam, located just upstream of the Sprague River's confluence with the Williamson River, is estimated to have restricted access to more than 95% of the potential spawning habitat for the LRS and SNS and is considered one of the more significant reasons contributing to the decline of the suckers (USFWS 1993). Although fish passage facilities on the dam have been installed, the dam has restricted annual migrations for endangered suckers (USFWS 1993); only a small percentage of the upstream migrating LRS and SNS successfully pass the dam through the existing fish ladder (Stern 1990). More detailed information about Chiloquin Dam is given in the 1992 biological assessment (Reclamation 1992a).

Blockage of the suckers at the dam during their upstream spawning migration forces the fish to spawn in the river reach downstream of the dam. Spawning of multiple related species within a relatively confined area may cause hybridization, although this has not been confirmed. LRS and SNS have been observed spawning together below Chiloquin Dam (L. Dunsmoor, Klamath Tribes, per. com.). Spawning and rearing habitat in reaches downstream of the dam are very likely limited. In addition, mass spawning of the suckers in confined areas close to UKL may create adverse density-dependent conditions limiting recruitment of larval suckers (e.g., competition for limited food supply and rearing habitat in confined areas of the lower Williamson River).

Spawning habitat in the Sprague River have been degraded by channelization, sedimentation, increased water temperatures, high nutrient concentrations, and the resulting periphytic algae and aquatic macrophytes. These problems originate in the Sprague River Valley, upstream of the present-day spawning areas, where agricultural activities have degraded the riparian habitat. In addition to the resulting loss of spawning habitat, the Sprague River is a major contributor of excess nutrients to the hypereutrophic UKL. Long-term success of spawning habitat restoration efforts in this river system depend almost entirely on rehabilitation of the upstream reach of the Sprague River (USFWS 1992).

9.8 Keno Reservoir

At least 55 unscreened private and irrigation district agricultural diversions exist on Keno Reservoir. Oregon Department of Fish and Wildlife has eight diversions for the Miller Island Wildlife Area, three of which are screened and plans are underway to screen others.

Further downstream agricultural diversions from the main stem of the Klamath River between the California-Oregon border and Copco Reservoir #1 provide water to private landowners through a lease of water rights (Beak Consultants, 1987). While these structures are relatively large, they probably do not impede fish passage in this river reach (F. Shrier, PacifiCorp, per. com.). More detailed information about these diversions are described in the 1996 biological assessment (Reclamation 1996a). The timing, volume, and the pattern of use of these irrigation diversions as well as their impact, on sucker populations are unknown although the impacts due to water quality and entrainment are likely. No other agricultural diversions are known in this vicinity (D. Maria, California Department of Fish and Game, per. com.).

Water quality on Keno Reservoir can at times be degraded due to treated sewage from two municipal sewage treatment plants, storm water and non-point source runoff from the City of Klamath Falls. Lumber mills along the Klamath River near Klamath Falls also contribute to water quality problems in the river. The Klamath Straits Drain, which receives return flows and storm runoff from private agricultural lands, municipalities, dairies, and refuges and the Klamath Project, contributes nutrients, sediment, herbicides and pesticides to the Klamath River. Other inputs include the Lost River Diversion Canal, Link River, and sediment sources. The highly enriched sediments were caused in part by decades of intensive lumber mill operations and log rafting on Lake Ewauna during the first 60-70 years of the 20th century. The impoundment of the nutrient rich waters in the reservoirs are known to contribute to algae blooms within the reservoirs and cause downstream algal nuisance conditions in the river.

Except for natural erosion along the banks of the Klamath River, there appears to be no other major source of sediment input to the Klamath River below Keno. The river reach below the J.C. Boyle Dam in Oregon to the California border was designated as the Klamath Scenic Waterway in 1988. The subsequent reach below the state line to Copco Reservoir is designated "Wild Trout Waters" by the CFDG.

9.9 Other Cumulative Effects

The transportation of hazardous materials by truck and train along the eastern and southern margin of UKL and over tributaries could result in spills and negative impacts to the listed and unlisted species in the basin's waters. Algae and Daphnia harvesting in UKL may result in the take of larval and juvenile suckers. The use of chemicals such as pesticides, herbicides, and mosquito or midge control chemicals could result in negative impacts to listed species throughout the basin. The diversion of water directly from UKL by private (non-Project) water users may result in the taking of suckers and reduction of habitat.

10.0 DETERMINATION OF EFFECTS

Reclamation's on-going operation of the Klamath Project may adversely affect the endangered Lost River and shortnose suckers due to: (1) loss of spawning and larval, juvenile, and adult rearing habitat and degradation of water quality related to regulation of water levels in reservoirs; (2) insularization of sucker populations increasing the risk of hybridization, introgression and loss of genetic variability due to dams and other facilities that have decreased the connectivity between different reservoirs and rivers in the Upper Klamath Basin; and (3) entrainment and loss of fish through diversions including irrigation canals and pumping plants. Reclamation has operated the Project in accordance with previous biological opinions and has initiated or completed most of the Priority 1 and 2 action items identified in the Lost River and Shortnose Sucker Recovery Plan. Reclamation has funded over 10.5 million dollars in ecosystem restoration projects that assist or benefit recovery of these species and purchased the 7,200-acre Agency Lake Ranch. Although the Project has affected, and continues to affect endangered suckers, Reclamation believes that sufficient progress is being made to complete the requirements of previous biological opinions and Recovery Plan action items. However, continuing operation of the Klamath Irrigation Project is still likely to adversely affect the shortnose and Lost River sucker and its proposed critical habitat. Continuing Project operations may affect likely to adversely affect threatened bald eagles due to loss of lake and marsh habitat supporting waterfowl and fish populations in the Basin during dry years.

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12.0 PERSONNAL COMMUNICATIONS

Dunsmoor, Larry. Fishery Biologist. Klamath Tribes, Chiloquin, Oregon.

Eilers, Joseph. Aquatic Ecologist. JC Headwaters, Inc. Roseburg, Oregon.

Hamilton, Andy. Fishery Biologist. Bureau of Land Management, Klamath Falls, Oregon.

Hainline, Jim. Wildlife Biologist. Klamath Basin National Wildlife Refuges, Tulelake, California.

Gutermuth, Brandt. Fishery Biologist. The New Earth Company. Klamath Falls, Oregon.

Kann, Jacob. Aquatic Ecologist. Klamath Tribes, Chiloquin, Oregon.

McCarley, Dave. District Manager. Langell Valley Irrigation District. Lorella, Oregon.

Opp, Ralph. Wildlife Biologist. Oregon Eagle Foundation. Klamath Falls, Oregon.

Shrier, Frank. Lead Scientist. PacifiCorp Company. Portland, Oregon.

Simon, David. Fishery Biologist. Oregon State University. Corvallis, Oregon.

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13.0 APPENDIX 1 ESA CONSULTATION REVIEW

13.1 Consultation History

Reclamation has consulted on the effects of Klamath Irrigation Project operations on species listed under the Endangered Species Act of 1973 in the past. A summary of these consultations is listed in Table 10.

Table 10. Consultation history for Klamath Project.

Date	Subject	Species	Product
June 14, 1989	USFWS Formal Consultation--Use of Acrolein in Canals and Drains within the Klamath Project Service area.	Shortnose sucker Lost River sucker	Likely to jeopardize.
August 14, 1991	USFWS Formal Consultation-- Effects of the 1991 operation of the Klamath Project.	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon	Likely to jeopardize the sucker species. No jeopardy to the Bald Eagle. No effect to the American Peregrine Falcon.
January 6, 1992	USFWS Formal Consultation-- Effects of the 1992 operation of the Klamath Project (interim biological opinion)	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon	Not likely to jeopardize the sucker species or the Bald Eagle. No effect to the American Peregrine Falcon.
March 27, 1992	Reinitiation of USFWS Formal Consultation--Effects of the 1992 operation of the Klamath Project.	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon	Likely to jeopardize the sucker species. No jeopardy to the Bald Eagle. No effect to the American Peregrine Falcon.
May 1, 1992	Reinitiation of USFWS Formal Consultation--Effects of the 1992 operation of the Klamath Project at Clear Lake Reservoir.	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon	No jeopardy to the consulted species.

July 22, 1992	USFWS Formal Consultation--Effect of the long-term operation of the Klamath Project.	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon	Likely to jeopardize the sucker species. No jeopardy to the Bald Eagle. No effect to the American Peregrine Falcon.
February 22, 1993	Reinitiation of USFWS Formal Consultation on the long-term operation of the Klamath Project - Upper Klamath Lake operations.	Shortnose sucker Lost River sucker	One-year modification of lake elevation 4141.0 on March 1, 1993.
August 11, 1994	Reinitiation of USFWS Formal Consultation on the long-term operation of the Klamath Project, with special reference to operations at Clear Lake Reservoir.	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon	Established new minimum elevation for Clear Lake Reservoir.
February 9, 1995	USFWS Formal Consultation on the use of pesticides and fertilizers on federal lease lands and acrolein and herbicide use on the Klamath Project rights-of-way located on the Klamath Project (reinitiation of consultation on the use of acrolein for aquatic weed control in Reclamation canals and drains).	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon Applegate's milkvetch	Not likely to jeopardize the sucker species. No effect to the Bald Eagle, American Peregrine Falcon, or Applegate's milkvetch.
April 7, 1995	NMFS Conferencing on the 1995 Operations Plan for the Klamath Project.	Steelhead (Klamath Mountain Province)	Letter of concurrence of not likely to jeopardize the steelhead.

February 2, 1996	Reinitiation of USFWS Consultation on the use of pesticides and fertilizers on federal lease lands and acrolein and herbicide use on the Klamath Project rights-of-way located on the Klamath Project.	Shortnose sucker Lost River sucker Bald Eagle American Peregrine Falcon	Not likely to jeopardize the species.
July 15, 1996	Reintiation of USFWS Consultation on PacifiCorp and The New Earth Company Operations, as Permitted by the Bureau of Reclamation on the Klamath Project	Shortnose sucker Lost River sucker	Not likely to jeopardize the species.
April 20, 1998	Amendment to the 1992 BO to cover Operation of Agency Lake Ranch Impoundment	Shortnose sucker Lost River sucker	Not likely to jeopardize the species.
July 13, 1998	Amendment to the 1992 BO dealing with Anderson-Rose releases	Lost River sucker Shortnose sucker	Not likely to jeopardize the species.
April 13, 1999	Bennett v. Badgley suit challenging the July 22, 1992 and August 11, 1994 biological opinions related to Clear Lake and Gerber reservoir	Lost River sucker Shortnose sucker	Motion to invalidate agency findings in the 1992 and 1994 BOs were granted related to RPAs for Clear Lake and Gerber reservoir
April 15, 1999	Amendment to the 1996 BO owing to lowered water levels in Upper Klamath Lake to reduce risk of flooding in spring 1999	Lost River sucker shortnose sucker	Not likely to jeopardize the species.
July 1999	NMFS Biological Opinion on 1999 Klamath Project Operations	Coho salmon	Likely to jeopardize the species.

August 18, 1999	Amendment to the 1995 BO on use of pesticides and fertilizers on leased lands and use of acrolein in canals operated by the Langell Valley Irrigation	Lost River sucker shortnose sucker	Not likely to jeopardize the species.
September 10, 1999	Revised amendment to the 1992 BO to cover operation and maintenance of Agency Lake Ranch impoundment	Lost River sucker shortnose sucker	Not likely to jeopardize the species.
January 12, 2000	Revision of the September 10, 1999 Amendment to the 1992 BO to cover operation and maintenance of Agency Lake Impoundment	Lost River sucker shortnose sucker	Not likely to jeopardize the species.
August 19, 2000	Clear Lake Releases-Amendment to the 1994 BO to cover additional water releases during August and September 2000	Lost River sucker shortnose sucker	Not likely to jeopardize the species.
September 4, 2000	7(d) determination for Upper Klamath Lake level	Lost River sucker Shortnose sucker	Avoid an irreversible and irretrievable commitment of resources.

13.2 Compliance with Biological Opinions

The most recent biological opinion applicable to Klamath Project operations was completed by the Service on July 15, 1996. The opinion addresses PacifiCorp and The New Earth Company Operations, as they overlap with Klamath Project lands and facilities. The July 22, 1992 and August 11, 1994 biological opinions list Reasonable and Prudent alternatives and Incidental Take Statement Reasonable and Prudent Measures and Terms and Conditions for project operations.

13.2.1 Reclamation's compliance with the 1992 and 1994 BOs is summarized below.

Status of Mitigation Measures Included in the 1992 Proposed Action

These measures were funded or performed by Reclamation. Information from these investigations were reviewed and incorporated in this biological assessment where appropriate.

1. Sucker Toxicity Studies - The National Biological Service (now the Biological Resources Division of the US Geological Survey; BRD) conducted acute lethal tolerance tests on larval and young of the year (YOY) juvenile sucker life stages from 1992 through 1995 (Saiki et al. 1999; Bellerud and Saiki 1995; Monda and Saiki 1994; Monda and Saiki 1993). Lethal levels of water temperature, dissolved oxygen, pH, and un-ionized ammonia were tested. In 1995, *in situ* tests were conducted with juvenile Lost River suckers (Martin 1997; Martin and Saiki 1999). Acute toxicity of acrolein to juvenile Lost River and shortnose suckers was evaluated by BRD (Midwest Science Center) in 1996 (Little 1997).

Chronic toxicity tests were performed by the University of Wyoming, Department of Zoology and Physiology in

1998 and 1999. Chronic exposures of low dissolved oxygen, high pH, and high ammonia were performed on larval and YOY Lost River suckers (Meyer et al. 2000). Bacterial challenge tests were conducted during fall 1999 on YOY Lost River suckers exposed to sublethal levels of ammonia (Snyder-Conn et al. 2000). This experiment was conducted through the coordinated efforts of University of Wyoming, U.S. Fish and Wildlife Service, and Oregon Department of Fish and Wildlife.

2. Life history, population dynamics, and environmental factors affecting suckers - BRD conducted life history and distribution and abundance studies at Clear Lake from 1992 to 1996 (Scoppettone et al. 1995; Perkins and Scoppettone 1996). Reclamation monitored water quality conditions using Hydrolab Inc. multiparameter instruments from fall 1991 through fall 1995. Feeding habits of endangered suckers were conducted in 1996 (Parker et al. 1998).

Population status and radio telemetry studies at Tule Lake were investigated from 1993-1995 by BRD and Reclamation (Scoppettone et al. 1995). Reclamation monitored water quality in Tule Lake using Hydrolab instrumentation from 1992-1995. In 1999, the Service (Klamath Basin National Wildlife Refuges) and Reclamation conducted additional radio telemetry and water quality studies at Tule Lake (Hicks et al. 2000). Reclamation has monitored sucker spawning runs in the Lost River below Anderson Rose Dam annually since 1991 (Reclamation 1998c).

From 1995 through 2000, BRD conducted adult sucker distribution and abundance studies on Upper Klamath Lake (BRD 1996, 1997; Shively et al. 2000; NBS 1996). Reclamation conducted adult sucker radio telemetry studies on UKL from 1993-1999 (Peck 2000). Oregon State University (OSU) monitored sucker spawning runs in the lower Williamson River in 1999 (Markle et al. 2000a).

OSU has been monitoring early life history and year class recruitment of suckers on Upper Klamath Lake annually since 1991 (Markle and Simon 1993; Markle and Simon 1994; Simon et al. 1995; Simon et al. 1996; Simon and Markle 1997; Simon, Markle and Terwilliger 1998; Logan 1998; Simon et al. 2000a,b; Cooperman and Markle 2000; Terwilliger et al. 2000). The Klamath Tribes have conducted investigations on sucker early life history and fathead minnow predation experiments (Klamath Tribes 1995, 1996). They have also assessed the effects of water management on sucker spawning and rearing habitat (Klamath Tribes 1991, 1995; Dunsmoor et al. 2000).

Extensive water quality monitoring and limnological investigations have been conducted on Upper Klamath Lake by the Klamath Tribes, USGS and Reclamation (Kann and Smith 1999; Kann 1998; Laenen and LeTourneau 1996; Barbiero and Kann 1994; Reclamation 1993a, 1993b; Forbes et al. 1998; Jassby and Goldman 1995; Ehinger 1992; Klamath Tribes 1995; PWA 2000 draft).

Reclamation conducted limited sucker population status surveys in Gerber Reservoir (1992-1995), Upper Klamath Lake (1993-1999), Lost River (1992, 1999), Lake Ewauna (1992), Copco (1993) and J.C.Boyle (1993) reservoirs (Reclamation, unpublished data). OSU studied the distribution and biology of suckers in J.C. Boyle, Copco and Iron Gate reservoirs in 1998 and 1999 (Desjardins and Markle 2000).

3. Assess external nutrient loading to UKL - USGS conducted an external nutrient loading study from 1992 through 1994 (Williams 2000 draft). Their study focused on the large tributaries to Upper Klamath Lake. Reclamation (Denver Technical Service Center) monitored nutrient loading and water quality in the Agency Lake watershed from 1990-1996 (Reclamation 1993a, 1993b; Reclamation, unpublished data). The Klamath Tribes have been conducting external nutrient loading monitoring since 1991 around Upper Klamath Lake (Kann and Walker 1999; Reclamation 1993a, 1993b). USGS evaluated nitrogen and phosphorus loading from drained wetlands adjacent to Upper Klamath Lake in 1993-1995 (Snyder and Morace 1997).

4. Compilation and analysis of past water quality investigations in Klamath Basin - U.C. Davis completed a compilation and analysis of water quality data in the area around Tule Lake (Kaffka et al. 1995). Reclamation has gathered other published water quality oriented reports and has compiled unpublished sources of information from past studies.

5. Taxonomy of Klamath Basin suckers - Reclamation funded work by Oregon State University (OSU) on larval and juvenile sucker identification and taxonomy using morphometrics and biochemical methods from 1991-1996 (Markle and Simon 1993; Markle et al. 2000b). From 1996 through 1999, OSU investigated nuclear DNA microsatellite

markers to help identify all life history stages of Klamath Basin suckers (Wagman 1999, 2000a, 2000b). In 1999 and 2000, OSU conducted a meristic and morphometric analysis of adult suckers (Markle et al. 2000b).

6. Monitor spawning use at springs - The Klamath Tribes have been monitoring spawning at Sucker Springs intermittently since about 1989 (Klamath Tribes, unpublished.data). Reclamation also monitored sucker spawning at Sucker Springs and Barkley Springs from 1992 to 1996 (Reclamation 1996a). In 1993, Reclamation identified other springs used for spawning along the east side of UKL (Reclamation 1996a). In 1995, the Tribes employed methods to quantify spawning success at Sucker and Ouxy Springs (Klamath Tribes 1995). They also evaluated the effects of cold water intrusion at Sucker Springs, spawning substrate utilization, and flatworm predation on sucker eggs (Klamath Tribes 1995). BRD monitored spawning at several locations on the east side of Upper Klamath Lake 1996-2000 (Perkins et al. 2000a; Shively et al. 2000a).

7. Locate springs in UKL and enhance substrate - OSU identified more than 130 shoreline springs in Upper Klamath Lake during shoreline habitat surveys in 1994 (OSU unpublished data). Sucker spawning substrate enhancement was initiated at Sucker Springs in 1987 by Oregon Department of Fish and Wildlife, Klamath Tribes, and U.S. Fish and Wildlife Service. However, because most UKL springs are also habitat for endemic snails, no substrate enhancement has been performed since 1995 (Frest 1998). Addition of substrate may be detrimental to these snail populations and requires further assessment.

8. Spawning enhancement at Barkley Springs - Reclamation in cooperation with Klamath County, owners of the spring, implemented two sucker spawning habitat enhancement projects. In 1993, Reclamation enhanced two potential spawning sites at Barkley Springs by placing gravel near spring discharges. In December 1995, Reclamation rerouted water from the northern most spring source to a site adjacent to the southern spring discharge to provide more water flow over a newly placed spawning gravel bed.

9. Assess methods to improve passage at Sprague River Dam - Reclamation funded a study by The Nature Conservancy to develop a conceptual design and cost estimate for upstream fish passage facilities at the Sprague River Dam (TNC 1996). In 1996, Reclamation conducted a bathymetric survey of the impoundment upstream of the Sprague River Dam to evaluate sediment deposition and collect site data for fish passage alternatives (Reclamation, unpublished data). Reclamation also developed a conceptual design for fish passage using rock weirs.

10. Assess marsh restoration - Reclamation funded a study to evaluate benefits of wetland restoration and prioritize sites to improve water quality, and provide habitat for endangered suckers and other wildlife in the Upper Klamath Lake watershed (Gearheart et al. 1995; Anderson 1998). Reclamation has assisted with wetland restoration efforts on the Wood River Ranch (BLM) and Tulana Farms (The Nature Conservancy) by providing O&M staff and equipment and engineering services. Reclamation has actively participated in the Lower Williamson River Restoration Team. Reclamation's Denver Technical Service Center completed a study on Hanks Marsh focusing on seasonal water quality and vegetation mapping (Salas 1995).

Reclamation, which administers ecosystem restoration funds provided under the Oregon Resource Conservation Act of 1996, funded a marsh restoration project in 1999. It is located on the Root Ranch in the Wood River area. This project was designed to demonstrate the applicability, effectiveness, and transferability of constructed wetlands in treating irrigation runoff. In 1998, Reclamation purchased the 7,200-acre Agency Lake Ranch adjacent to Agency Lake. A wetland has become reestablished as Reclamation has managed the property as a shallow storage area. Water quality and wetland vegetation response has been monitored each year. Two studies were funded in 2000 to conduct water bird surveys and detailed vegetation monitoring on the Ranch. Reclamation funded two Upper Klamath Lake wetland vegetation mapping projects in 1998 and 1999 to identify existing marsh vegetation distributions (Dunsmoor et al. 2000; Reclamation, unpublished data).

11. Determine prey species and foraging distribution of bald eagles at Gerber Reservoir, due to drought stress - Reclamation funded a bald eagle monitoring study conducted by BLM in 1992 and 1993. BLM provided a report in 1994 summarizing eagle foraging habits, and reproductive success at Gerber Reservoir. The two eagle pairs using Gerber Reservoir appeared to obtain adequate forage during the drought year although nesting success was poor. BLM and OSU have continued to monitor occupancy and reproductive success of bald eagle nests at Gerber Reservoir from 1994-2000. Reclamation has provided funding to support ongoing monitoring of bald eagle reproductive success in the Upper Klamath Basin from 1998-2000.

12. Support ecosystem recovery for Klamath Basin - In 1993, Reclamation and the Service established the Ecosystem Restoration Office (ERO) to coordinate ecosystem restoration in the Klamath Basin. Reclamation provided substantial staffing, clerical support, office space, equipment, and vehicles for this office from 1993-2000. ERO has been working with Klamath Basin natural resource management agencies, tribes and other entities in accomplishing ecosystem restoration. Major focus of ERO has centered on long-range planning, GIS development, ecosystem restoration projects, and public education. Since 1993, Reclamation has provided about $10.5 million for ecosystem restoration projects.

Reclamation is also a member of the Upper Klamath Basin Working Group, established in 1996 through the Oregon Resource Conservation Act. From 1999-2002, Reclamation will administer ORCA grants that focus on ecological restoration, economic stability, and reduction of drought impacts. One million dollars per year are allocated for this program that requires equal or greater non-federal match.

13. Investigate a new channel at mouth of Willow Creek (Clear Lake) - It was initially surmised that because the mouth of Willow Creek enters Clear Lake in close proximity to the dam, that it might be better if a new channel was cut through the east lobe away from the dam. This was expected to deepen the channel to provide better upstream passage for migrating adults during low lake level years and protect emigrating larvae from being entrained through the dam outlet works. However, because numerous archeological sites exist in the proposed area Reclamation determined that this action is not feasible. Also, during years when the reservoir is low enough that this channel is needed for passage out of Clear Lake, spawning access is also restricted in Willow Creek due to low stream flows (Perkins and Scoppettone 1996). Reclamation collected detailed bathymetric data in Clear Lake from Willow Creek to the dam in 1991.

14. Genetic relationships - OSU and U.C. Davis performed preliminary protein electrophoresis analyses in 1990 on shortnose, Lost River and Klamath largescale suckers (Moyle and Berg 1991; Harris and Markle 1991). In 1994 and 1995 UCLA conducted additional electrophoresis work funded in part by Reclamation (Buth and Haglund 1994).

Reclamation collected suckers representing five species and several populations throughout the Upper Klamath River Basin for taxonomic and genetics study in 1993. In 1999 and 2000, Reclamation funded Arizona State University to conduct a mitochondrial DNA study on Klamath Basin suckers (Dowling 1999, 2000). U.C. Davis tested allozymes, AFLP, and nuclear microsatellites as possible sources of species diagnostic markers from 1998-2000 (Tranah and May 1998, 1999).

15. Watershed improvement - Reclamation has funded approximately $10.5 million in watershed improvement projects such as riparian fencing, wetland restoration, in-stream aquatic habitat restoration, erosion control, water quality improvement. In 1998, Reclamation purchased Agency Lake Ranch. In 1998 and 1999 no water was pumped off the property reducing the nutrient loading to Agency Lake.

16. Internal nutrient loading on UKL - Nutrients in the lake bottom sediments, primarily nitrogen and phosphorus compounds, are thought to be important sources for the yearly massive blue-green algae blooms in Upper Klamath Lake. Researchers have not established a methodology for direct measurement of this component of the total nutrient load. However,it has been estimated by quantifying all other components of the nutrient budget including inflow, outflow, and water column concentrations and loadings (Kann and Walker 1999). Reclamation funded a paleolimnological study of Upper Klamath Lake in 1999 that will provide valuable information on sediment characteristics and internal nutrient loading (Joseph Eilers, JC Headwaters, per. com.).

17. Recruitment study - Reclamation has funded larval and juvenile sucker ecology and recruitment studies by OSU in UKL since 1991 (Markle and Simon 1993; Markle and Simon 1994; Simon et al. 1995; Simon et al. 1996; Simon and Markle 1997; Simon et al. 1998; Logan 1998; Terwillinger et al. 2000; Markle et al. 2000a; Cooperman and Markle 2000; Simon et al. 2000a, 2000b). The Klamath Tribes conducted habitat utilization studies on larval and juvenile suckers in 1995 focusing on emergent vegetation versus open water habitat utilization (Klamath Tribes 1995). Reclamation funded a larval and juvenile sucker entrainment study on the A-Canal in 1997 and 1998 (Gutermuth et al. 2000).

18. Investigate feasibility of new storage in Lost River system - Reclamation reviewed several water development

reports prepared for the Lost River watershed including: *A Status Report on Water Resources Development in the Upper Lost River Watershed* (Reclamation 1968), *Malone Watershed Report* (Reclamation 1970a), *Clear Lake Watershed Report* (Reclamation 1970b), *Gerber Watershed Report* (Reclamation 1970c), and *A Concluding Report on Possibilities for Water Resource Development and a Supplemental Water Supply for Langell Valley* (Reclamation 1972). Reclamation provided Langell Valley Irrigation District a grant in 1999 to develop a water conservation plan. Reclamation is conducting a feasibility study to raise Gerber Dam in 2000-2001. The Oregon Department of Geology and Mineral Industries is conducting geological studies in the Lost River watershed to help assess the ground-water resources in the Upper Klamath Basin.

19. Monitor refugial areas - OSU evaluated sucker distribution in several freshwater inflow areas in 1992 (Logan and Markle 1993). Reclamation has also conducted limited sucker population monitoring and water quality monitoring in these areas (Reclamation unpublished data). Since 1992, there has been new information collected that indicates that clear freshwater inflow areas are generally not frequently used as refugial areas by adult suckers (Reclamation 1996a). Mostly sick and dying suckers have been observed in these areas. When poor water quality conditions occur on UKL adult suckers appear to use areas in the lake adjacent to freshwater inflow areas.

20. Re-evaluate flood plan for Tule Lake - Reclamation has re-evaluated this plan. A report was developed by the Denver Technical Service Center in December 1996 (Reclamation 1996b). The report concluded that lake levels required under the 1992 BO increase the risk of overtopping dikes around Tule Lake only slightly.

13.2.2 Reclamation's Compliance With Reasonable and Prudent Alternatives in the 1992 and 1994 Biological Opinions.

1. Upper Klamath Lake - From 1992-1995, Reclamation complied with the minimum water surface elevations established in the 1992 BO with two exceptions. The first exception occurred in 1993; the March 1 minimum elevation of 4141 was not met because extremely cold weather delayed runoff from a substantial snow pack. However, sucker spawning began about March 15 at which time the lake was above 4141. The second exception occurred in 1994, an extreme drought year. UKL attained a minimum elevation of 4136.8, 0.2 feet below the 4137 minimum for compromise years.

The 1992 BO allowed variance from required minimum lake elevations in no more than four years in a 10-year period. Such operations occurred in 1992 and 1994 when end-of-season minimum elevation of 4137 was implemented. In 1993 and 1995 Reclamation operated and exceeded the more protective elevation (4139).

In 1996, Reclamation formally consulted with the Service on PacifiCorp's and New Earth Corporation's operations, as permitted by Reclamation. In this consultation, new scientific information was evaluated (Reclamation 1996a) and the Service assumed Reclamation would operate to more restrictive "low range" (i.e. higher) elevations than those presented in the 1992 BO (USFWS 1996). These elevations were: February 15 – 4141.5, April 15 - 4142.6, May 31 – 4142.6, July 15 – 4141.6, September 30 – 4138.2, December 30 – 4140.0. Reclamation met or exceeded those elevations in 1996. In the 1997-2000 Klamath Project annual operations plans, Reclamation proposed the "low range" elevations with a modification for end of September. The 1996 BO September 30 "low range" elevation was 4138.2 versus 4139.0 for 1997-2000. Reclamation met or exceeded all "low range" elevations except for April 15, 1999. Reclamation consulted with the Service and obtained an amendment due to high risk of flooding that year (USFWS 1999a).

Reclamation was required to implement a method to reduce entrainment of larval, juvenile, and adult suckers into the A-Canal by July 1997. Reclamation provided a grant to the Klamath Irrigation District (KID) in 1995 to evaluate sucker entrainment and identify alternatives for entrainment reduction. A final report was completed in 1997 (Natural Resource Scientists 1997). Several meetings were held in 1995 and 1996 to discuss this issue with representatives of the KID, Tule Lake Irrigation District (TID), Oregon Department of Fish and Wildlife (ODFW), Cell Tech, Reclamation and the Service. From these meetings, the group agreed that entrainment reduction strategies and associated fish passage issues at Link River Dam should be integrated. Subsequently, the Upper Klamath Lake Entrainment and Fish Passage Working Group was formed to integrate all fish entrainment and passage issues. The working group consists of Reclamation, Klamath Tribes, Service, KID, Cell Tech, PacifiCorp, TID, and ODFW. Reclamation facilitated meetings 2-3 times per year from 1997 through 1999 to discuss progress and recommend future activities.

In 1997, the Service requested that Reclamation conduct additional entrainment monitoring on the A-Canal to compare with entrainment monitoring data from Link River Dam and B- and C-Canals. Reclamation funded an A-Canal fish entrainment monitoring study in 1997 and 1998 (Gutermuth et al. 2000a). In 1998, Cell Tech evaluated several mesh sizes of wedge-wire screen material to determine debris loading characteristics and sizes of fish that were excluded (Gutermuth et al. 1998). Reclamation's Denver Technical Service Center collected field hydraulic data in the Link River near the A-Canal in preparation of development of a physical hydraulic model (Wahl 1999).

In April 1998, Reclamation received an amendment to the 1992 BO dealing with A-Canal sucker entrainment reduction (USFWS 1998a). The Service stated that Reclamation had made significant progress in seeking methods to reduce sucker entrainment in the A-Canal and Reclamation was granted a five-year extension (to 2002) to reduce entrainment.

In 1999, Reclamation's Klamath Basin Area Office hired a fish passage biologist to coordinate Reclamation's fish entrainment and passage activities. The University of Wyoming was contracted to conduct swimming performance tests of juvenile Lost River suckers in a range of water temperatures to help with the development of fish screen facility criteria (Meyer 1999). In 1999, Reclamation also performed field evaluations of Reclamation's Universal Stream Bottom Retrievable Flat Plate Fish Screen. Preliminary results were promising and plans were made to test two 100 cfs Reclamation-designed screens in the A-Canal during the 2000 irrigation season. Reclamation proceeded with the development of preliminary designs for the test installation during fall 1999 and developed draft specification and final drawings of the screens in Spring 2000.

In a March 29, 2000 letter to Reclamation, KID did not support Reclamation's prototype screen and instead wanted to pursue other flat plate screen alternatives. Reclamation and KID met with the Service and ODFW to discuss the conceptual screen designs and identify acceptable design criteria. Reclamation has provided KID with a grant to develop preliminary designs for A-Canal screens.

In 1996, the Service identified measures to quantify sucker entrainment at PacifiCorp and Cell Tech facilities in the 1996 BO (USFWS 1996). These studies have been completed (Gutermuth et al. 1997, 1998, 1999, 2000b).

2. <u>Clear Lake Reservoir</u> - RPA's in the 1992 BO included minimum water levels for Clear Lake Reservoir. These minimums were met in 1992 and 1993. A new biological opinion issued in August 1994 modified the RPA's described in the July 1992 BO for Clear Lake Reservoir. The 1994 BO required a minimum elevation of 4521 on October 1. This elevation was exceeded from 1994 through 2000. The BO also called for development of a water conservation plan. The Langell Valley Irrigation District initiated work on this plan in 1999 with a grant provided by Reclamation. CH2MHILL and FloSonics, Inc. conducted a water conservation assessment of Horsefly Irrigation District in 1997 (CH2M HILL 1998). Their study would be useful in further assessments and water conservation planning. Reclamation's Klamath Basin Area Office hired a water conservation specialist in 1999 to work on water conservation activities throughout the Klamath Project.

The 1994 BO requires Reclamation to release no water from Clear Lake until April 15 to protect larval suckers emigrating downstream in Willow Creek from being entrained at the dam. This RPA was met in 1993, 1995, and 1996. In 1994, flow releases of 13-33 cfs were made from April 4 - 8. Diversions were shut off from April 8 - 19. During this drought year, there appeared to be poor access to Willow Creek by spawning suckers migrating from Clear Lake because of low flows. Apparently, water depths in lower Willow Creek were inadequate for passage of most suckers migrating out of Clear Lake. Nevertheless, some emigrating larvae were sampled from Willow Creek during spring and summer (Scoppettone et al. 1995). Substantial releases were made during late winter and spring in 1997-1999 for Safety of Dams operations. Salvage operations were performed in 1997 and 1999 after flood control releases were stopped (Reclamation 1998a, 2000b). In 1998 flows were maintained until fall when normal irrigation deliveries are stopped.

Other RPAs call for aeration during periods of poor water quality and salvage of suckers if water quality or quantity conditions threaten them. Reservoir conditions have not required implementation of these RPA's.

In 1997, the structural integrity of Clear Lake Dam was investigated under the Reclamation Safety of Dams Act. Reclamation determined that the dam does not meet state-of-the-art design standards and modified the standard operating procedures (Reclamation 1999b,c). The maximum operating level was lowered substantially from the original design capacity to reduce the potential for seepage problems experienced when the lake is at high levels. Reclamation consulted with the Service on a reservoir restriction operation of Clear Lake Reservoir (Reclamation 1999b) and the Service concurred that permanent operation of the reservoir at low elevations would likely jeopardize the sucker populations in Clear Lake (USFWS 1999d). Based on this determination, Reclamation made plans to replace the existing dam with a roller-compacted concrete dam in 2001-2002. Operations will remain the same as with the old dam except that reservoir level restrictions will be removed. Reclamation has informally consulted with the Service on the impacts of dam replacement activities on endangered suckers.

3. Gerber Reservoir - This RPA calls for no water deliveries when the surface elevation is 4799.6 or less. In 1992, irrigation deliveries had to be shut off in May to comply with this RPA. Water levels were well above the minimum from 1993 through 2000.

4. Tule Lake - This RPA calls for minimum surface elevations of 4034.6 from April 1st to September 30th and 4034.0 from October 1 to March 31. These elevations were met or exceeded from 1992-2000. Another RPA called for a minimum flow of 50 cfs beginning April 1 for at least 4 weeks to allow sucker spawning below Anderson-Rose Dam. Flows of at least 50 cfs were maintained in the Lost River from April 1 until June 1 in 1993, 1994 and 1996. In 1995, 30 cfs was maintained in the river beginning April 1. The lower flow was necessary to provide acceptable flow conditions in a newly constructed spawning channel. Spawning and larval recruitment occurred under the lower flows. The Service in a September 25, 1995 memorandum to Reclamation, concurred that this variance in the RPA was acceptable for 1995. The spawning channel washed out during the winter of 1996 at high flows and has not been replaced.

In 1998, Reclamation requested modification of the Tule Lake RPA based on new scientific data (June 11, 1998 letter). The Service amended the 1992 BO on July 13, 1998 (USFWS 1998c). The new RPA requires a minimum flow of 30 cfs beginning April 15 for at least 4 weeks to allow sucker spawning and emigration of larvae. Reclamation complied with the amended RPA's in 1999 and 2000.

13.2.3 Compliance with the 1992 Incidental Take Statements

The Service anticipates that operation of the Klamath Project, described for the 1992 and 1994 BOs, would result in an indeterminant level of take of Lost River and shortnose suckers in the form of harassment, harm, or killing. The Service anticipated take due to entrainment from Clear Lake and Gerber Reservoir into the Lost River and associated delivery systems, entrainment from Upper Klamath Lake into the A-Canal and associated delivery systems, entrainment from Tule Lake via pumps or diversions into associated delivery systems, negative effects of poor water quality, chemical vegetation control, entrainment in pumps, increased predation, and dessication of suckers in delivery system features, entrapment of suckers in the Gerber and Clear Lake reservoirs' outlet structures, and negative effects on suckers inhabiting Klamath Project lakes and reservoirs when water quality or quantity is reduced to stressful levels. To minimize the impact of incidental take, the Service established several Reasonable and Prudent Measures and Terms and Conditions that are non-discretionary.

Reclamation is required to salvage suckers that remain in the canal systems that emanate from project reservoirs after those canals have been drawn down and drained. Annual salvage plans must be presented to the Service and state resource agencies for approval prior to any salvage operation. Reclamation has developed salvage plans annually since 1991; sucker salvage has been performed according to approved plans. During annual salvage operations, the Service anticipates that up to125 individual fishes may be killed. During the nine years of salvage operations, Reclamation has not exceeded this number (Reclamation 1992a, 1993c, 1994a, 1994b, 1996c, 1997, 1998a, 1999a, 2000b).

Reclamation is required to salvage suckers from any lake or reservoir in the Klamath Project if water quality or quantity data indicates conditions that threaten the endangered suckers and the Service determines the action is warranted. Water quality and quantity must be monitored at least weekly, in any project water known to support endangered suckers, during periods when those waters would have the potential to require a salvage operation. Reclamation implemented an extensive water quality monitoring program beginning in 1992 on all major project reservoirs using Hydrolab Inc. water quality instrumentation. This intensive program was conducted through 1995. Water quality monitoring was discontinued in Gerber and Clear Lake reservoirs after 1995 because these reservoirs were maintained at high levels from 1995-2000 and evaluation of the 1992-1995 water quality data indicated that conditions remained good during higher water years (1993, 1995).

Poor water quality conditions have occurred yearly at Upper Klamath Lake during the summer months. Maintaining higher lake levels is considered the only action under Reclamation's control that can positively affect UKL water quality. Aeration was implemented at Gerber Reservoir from summer through winter of 1992-93, Clear Lake Reservoir during summer 1992 and winter 1993 at Tule Lake. However, these activities provided only very localized benefits.

Reclamation was also required to develop and implement a long-term plan to prevent and minimize take associated with the Klamath Project. A draft plan was developed during the summer of 1995 and circulated to the Service and state resource agencies. Reclamation is waiting for direction from these agencies on how to proceed.

A comprehensive survey of the Klamath Project service area was required to delineate the location of potential sources of take, develop and implement a program to reduce or eliminate this take, and for education purposes notify landowners and/or irrigation districts that the potential for take exists and advise them of protection afforded listed species under the Act. This was a required activity, to be completed by July 22, 1995. The field portion of the survey is nearly completed. Reclamation plans to complete the written report by September 2001.

13.2.4 Reporting Requirements

Upon locating dead, injured, or sick endangered species initial notification must be made to the nearest Service Law Enforcement Office. Reclamation has contacted the local agent when dead fish have been found. The Service's Ecological Services Office (Portland Field Office 1992-1995; Klamath Falls Field Office 1996-2000) has also been contacted as required.

13.2.5 Conservation Recommendations

The Service recommended that Reclamation assist the Klamath Tribes in improving larval rearing habitat in the lower Williamson River. Reclamation has funded studies designed to better understand larval sucker rearing requirements (Cooperman and Markle 2000) and potential factors limiting larval sucker survival (Klamath Tribes 1995, 1996). Reclamation also funded an ecosystem restoration project in 1994 submitted by a private land owner at Tulana Farms located on the west side of the lower Williamson River. The project called for the planting of willows and other riparian vegetation along the riverbanks. It was anticipated that this project would enhance larval and juvenile rearing habitat. Reclamation has provided technical support and engineering services to the Nature Conservancy in the restoration of the lower Williamson River delta from 1996-2000 (Tulana Farms property).

13.2.6 Compliance with the July 15, 1996 Biological Opinion on PacifiCorp and The New Earth Corporation Operations as permitted by Reclamation

Reclamation was the responsible entity to identify ownership of the fish ladder on Link River Dam by December 31, 1996. Reclamation provided a letter to the Service in December 1996 stating that Reclamation was the owner of Link River Dam and the adjoining fish ladder (December 12, 1996 letter).

Reclamation was also required to complete a fish ladder report by December 31, 1998. Reclamation has been working on fish passage issues since early 1998 when Reclamation was requested by the Service to lead the Upper Klamath Lake Entrainment and Fish Passage Working Group. Reclamation with assistance from fish passage engineers from the Denver Technical Service Center developed conceptual designs for a new ladder at Link River Dam in the fall of 1999 (Reclamation, unpublished data).

The Service made several important assumptions in completing the 1996 BO (USFWS 1996). They include: 1) The Service assumed, in the interim between this consultation and completion of the Upper Klamath Lake endangered sucker consultation by spring 1997, water elevations and corresponding target dates in Reclamation's "low range elevations" proposal would be achieved during 1996; 2) The Service assumed Reclamation will complete the anticipated Upper Klamath Lake endangered sucker consultation by spring 1997. The Service anticipates the Upper Klamath Lake endangered sucker consultation will address other Project impacts and summarize and/or update new data not addressed in these PacifiCorp and The New Earth Company biological and conference opinions; 3) The Service assumed new information presented in the Upper Klamath Lake consultation would be integrated into Reclamation's and PacifiCorp's management of Upper Klamath Lake water elevations. These operations should provide annual lake levels in 1997 and beyond that are conducive to enhanced endangered sucker survival while proposed long-term habitat restoration activities are implemented and biotic response is monitored; 4) The Service assumed all ongoing research and monitoring, as specified under the July 22, 1992 Project long-term biological opinion, would continue; 5) The Service assumed that, in the long term, Lower Williamson River restoration efforts would prove successful and benefit all life stages of endangered suckers, reducing the need for short-term protections; 6) The Service assumed proposed short-term actions will remain valid until long-term Lower Williamson River restoration efforts are determined successful and Service analysis of species recovery potential validates relaxation of short-term measures.

Assumptions 1 and 4 were met. Assumption 2 and 3 did not occur, however, Reclamation operated Upper Klamath Lake elevations at levels above those identified as new "low range" minimums in the 1996 BO during 1997-2000. Assumption 5 has not been met.

PacifiCorp conducted a flood operations review and risk assessment for Upper Klamath Lake pursuant to Article 2.1 of the Terms and Conditions of the Incidental Take Statement (PacifiCorp 1996). This analysis was necessary to assess the risks of proposed lake elevations to benefit endangered suckers in Upper Klamath Lake. In the early part of this century, PacifiCorp built and strengthened dikes around the lake associated with reservoir operations after construction of Link River Dam in 1921. Dikes were built to reclaim vast wetlands around the shoreline of UKL.

Based on the analysis of stream flow data for the Williamson River and reconstructed inflows to UKL for the period of record (1905-1996), maximum allowable elevations were computed by month and flood frequency. Using a 50-year flood frequency all elevation proposed in this assessment to protect suckers are less than the maximum allowable. Using a 100-year flood frequency only the February 15 elevation of 4141.5 is above the maximum elevation allowed (4141.3 feet). PacifiCorp has indicated that they will accept the additional risk of 4141.5 in February.

Other BO Terms and Conditions were required of PacifiCorp and The New Earth Corporations. Details of these requirements will not be discussed here. However, Reclamation understands that all BO requirements have been met to date. Some of these terms and conditions have been amended.